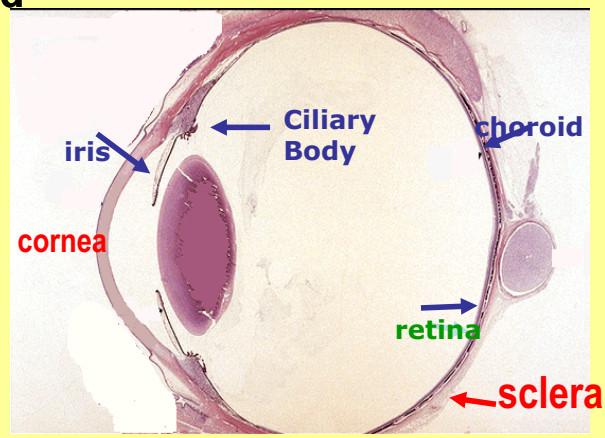
THE EYE

Paired 22 mm diameter fluid- filled globes- adapted for the detection of:

light - form - and color.



The walls composed of:
3 layers or coats

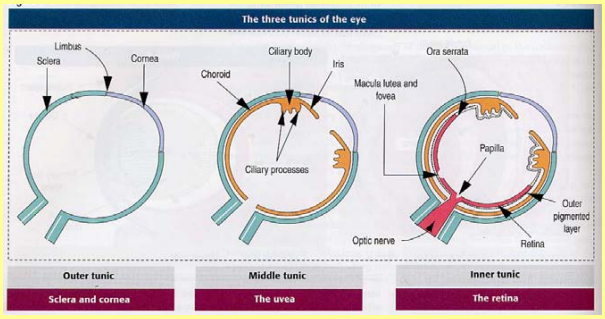
1. **Outer: supporting layer**

   CORNEA -- SCLERA

2. **Middle: vascular (uveal) layer**

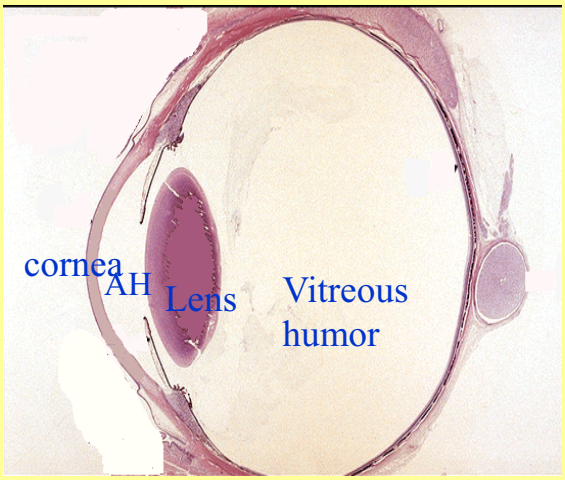
   IRIS -- CILIARY BODY -- CHOROID

3. **Inner: retinal layer (sensory)**
   - **RETINAL PIGMENT EPITHELIUM**
   - **NEURAL RETINA**



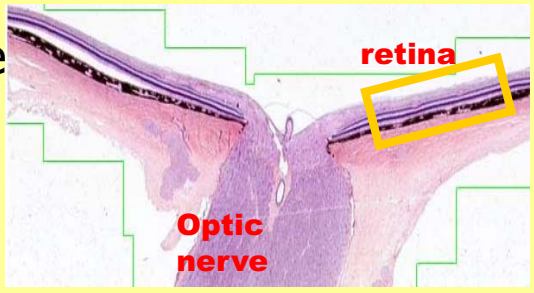
4 refractile elements

CORNEA -- AQUEOUS HUMOR -- LENS -- VITREOUS HUMOR



— Light enters the anterior aspect of the eyeball and passes through these refractile structures on the way to the light-sensitive retina

— At the posterior aspect of the eye , light falls upon a specialized, photosensitive neuroepithelium = RETINA



RETINA

The Retina

-- **A multilayered structure consisting of many different cell types.**

-- **These are subclasses of neurons which receive graded neural impulses from the photoreceptors cells.**

-- **Graded neural inpulses are transformed into patterned neural information transmitted to the brain.**

2 classes of light-sensitive photoreceptors:

RODS adapted for vision in dim light

CONES adapted for vision in bright light and for color vision

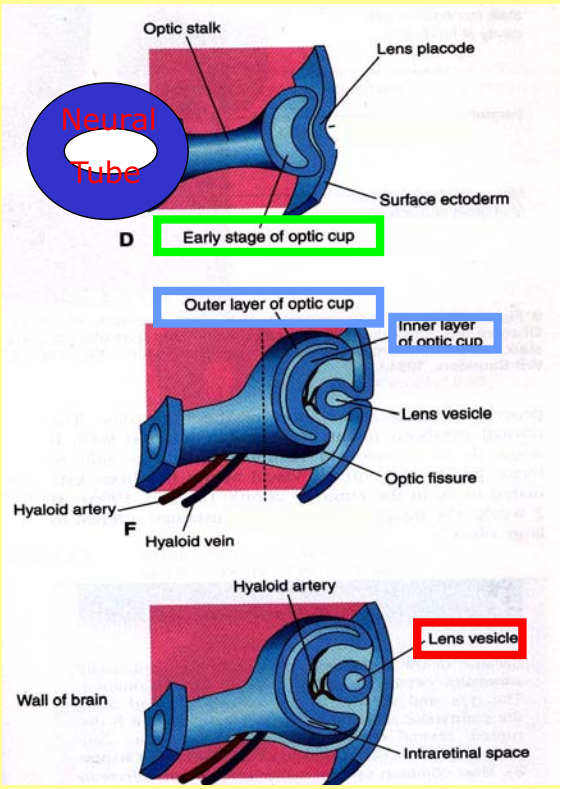
– **neural signals are transmitted from the retina to the CNS via the large OPTIC NERVE, which exits the posterior aspect of the eyeball.**

DEVELOPMENT OF THE EYE:

anterolateral outpocketing of the primitive neural tube in the third week of gestation called the OPTIC VESICLE at the level of the future diencephalon.

The optic vesicle is attached to the neural tube by a stem-like optic stalk.

the optic vesicle invaginates causing the anterior and posterior walls to come together to form the OPTIC CUP.



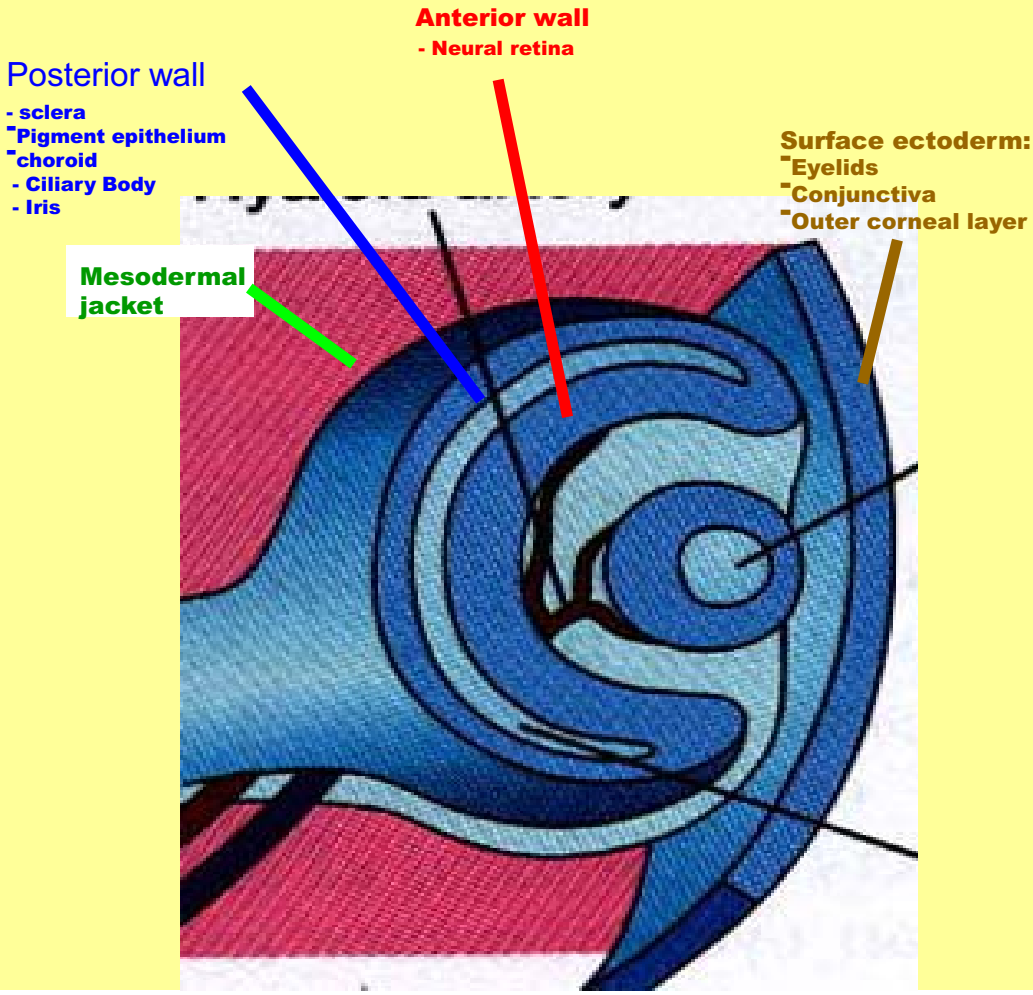
The posterior wall along with the surrounding mesoderm becomes:

- pigment epithelium of the retina

The anterior wall develops into

- the 9 layers of the neural retina.

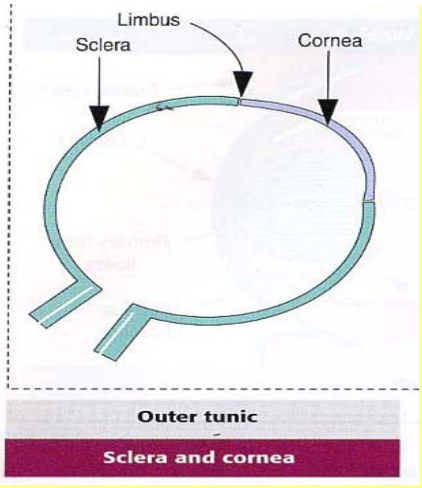
- **The optic cup grows outward to contact the surface epithelium of the embryo.**
- **This point of contact buds off a small mass of tissue which forms the lens vesicle from which the lens develops.**
- **mesoderm, closes over the posterior aspect of the optic cup and forms the supporting coat and vascular coat.**
- **The surface ectoderm develops into the external eye structures**
  - **eyelids**
  - **conjunctiva**
  - **outer epithelial layer of the cornea.**



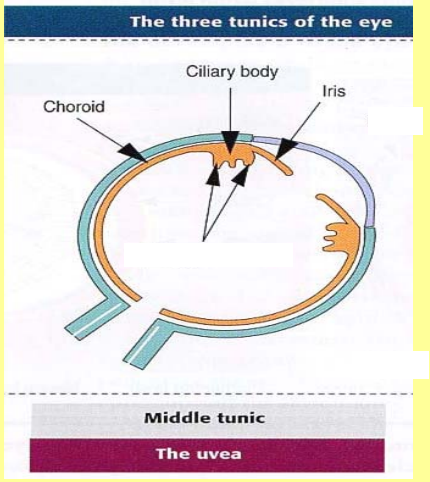
TUNICS OF THE EYE:
3 layers or coats.

1. The OUTER TUNICA FIBROSA
A tough fibrous coat of connective tissue.

-- anteriorly = CORNEA,
-- posterior = SCLERA.



2. The MIDDLE UVEAL OR VASCULAR COAT
From anterior to posterior, consists of the IRIS -- CILIARY BODY -- CHOROID LAYER.

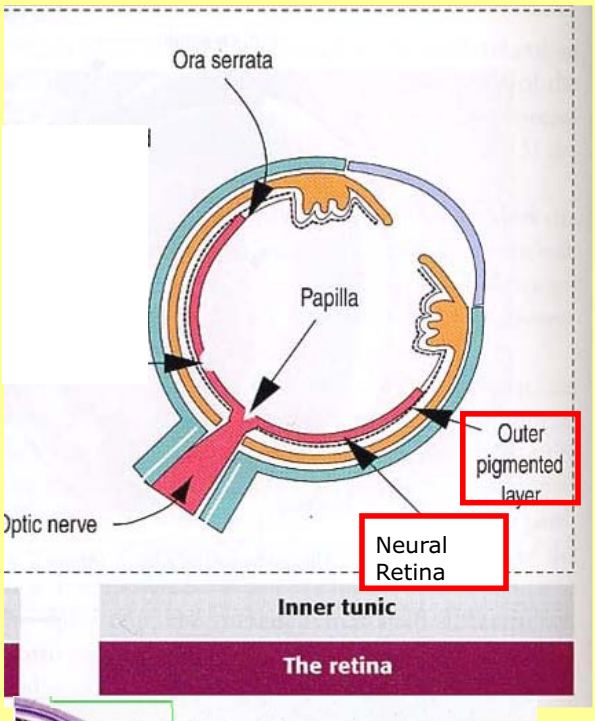


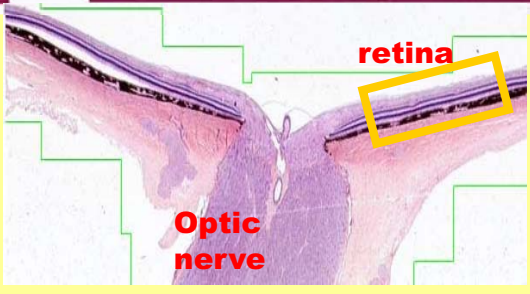
3. The RETINAL COAT consists of two sub layers.

a. The PIGMENT EPITHELIUM covers the posterior surface of the iris, the ciliary process, and the entire posterior wall of the eyeball in front of the choroid.

b. The overlying NEURAL RETINA covers the back of the eyeball up to the ciliary body at a juncture called the ORA SERRATA.

The retina develops as an outpocketing of the CNS and remains connected to it by the OPTIC NERVE.



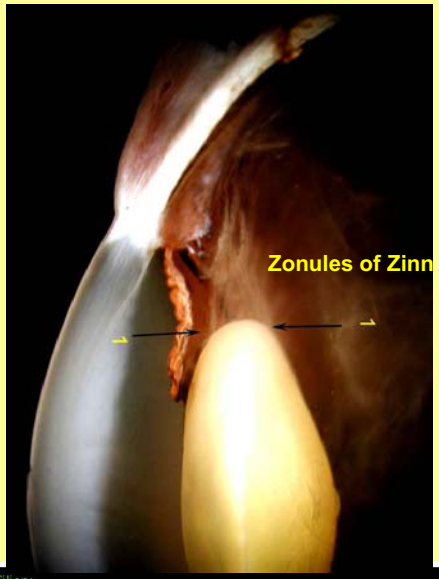


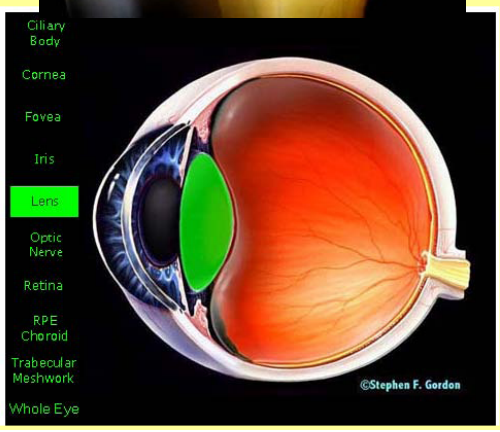
A translucent **LENS** is suspended just behind the iris

The lens is suspended by a set of **suspensory ligaments** or **ZONULES OF ZINN** which attach:

-- at one end to the margin of the lens

-- and at the other end to the cilliary body (processes).





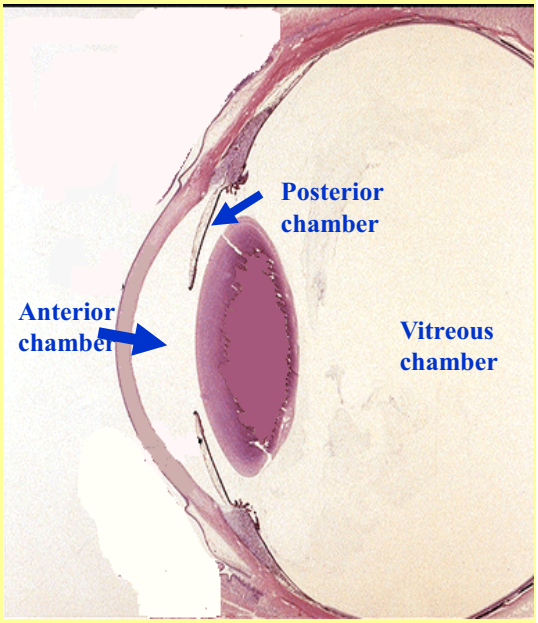
CHAMBERS OF THE EYE:

The internal aspect of the spherical eyeball is divided into 3 chambers

1. **ANTERIOR CHAMBER**: bounded by the iris and the cornea

2. **POSTERIOR CHAMBER**: bounded by the lens, iris and ciliary body

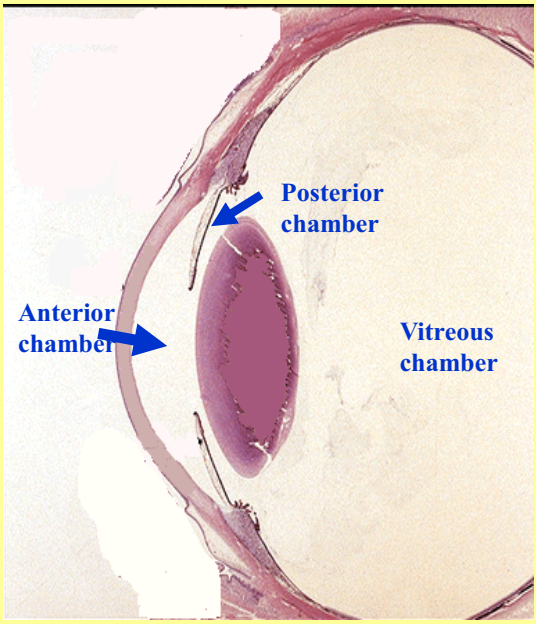
- Both are filled with:
  - S a nutritive ultrafiltrate of plasma= **AQUEOUS HUMOR,**
  - S produced by the epithelium of the ciliary body.



3. VITREOUS CHAMBER:

-- bounded by the lens and the posterior wall of the eyeball

-- filled with a transparent homogeneous gelatinous intercellular substance -- **VITREOUS BODY**, whose source is not known

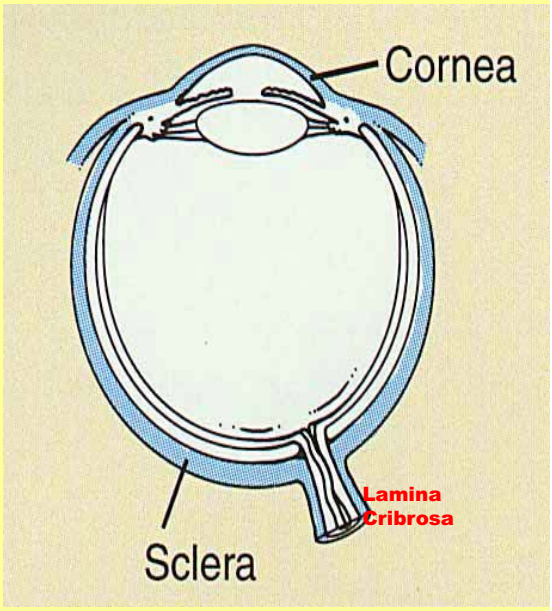


The vitreous body helps

- the eyeball to hold its shape
- hold the lens and retinal layers in place.

MICROANATOMY OF THE EYE

TUNICA FIBROSA:
the external-most coat of the eyeball composed of the **SCLERA** posteriorly and the translucent **CORNEA** anteriorly.



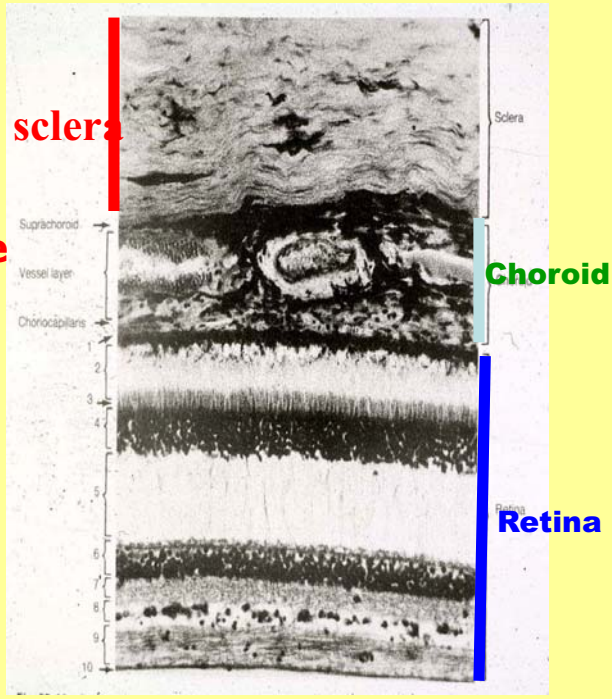
SCLERA

- Tough white fibrous tissue covering the **posterior 5/6** of the tunica fibrosa
- forms the capsule for the back part of the eyeball.

The sclera consists of 3 layers

1. **THE EPISCLERA The external surface layer of dense, vascularized connective tissue attached to a dense layer of connective tissue surrounding the eye called TENNON'S CAPSULE.**

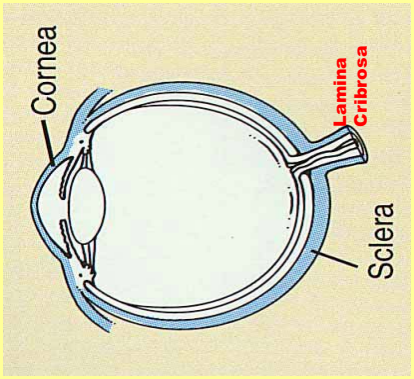
2. **SCLERAL STROMA - sheets of collagen fibers (type I) in different orientations parallel to the surface.**



-- **The collagen sheets are interspersed with MELANOCYTES, FIBROCYTES and amorphous GROUND SUBSTANCE.**

-- **A network of elastic fibers are also dispersed among the collagen bundles.**

-- **the stroma is relatively avascular, with a high water content gives it a white opaque color.**



3. **LAMINA FUSCIA**

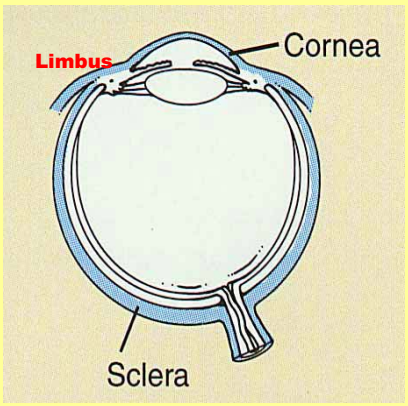
-- the innermost layer of the sclera

-- consists of fine collagen fibers which blend with the immediately adjacent choroid layer of the eye.

The sclera is continuous with the dura mater covering the optic nerve.

The optic nerve pierces the sclera as it exits the eyeball at the LAMINA CRIBROSA

CORNEA



anterior 1/6 of the tunica fibrosa is a

- **colorless transparent structure = the first optical element of the eye.**

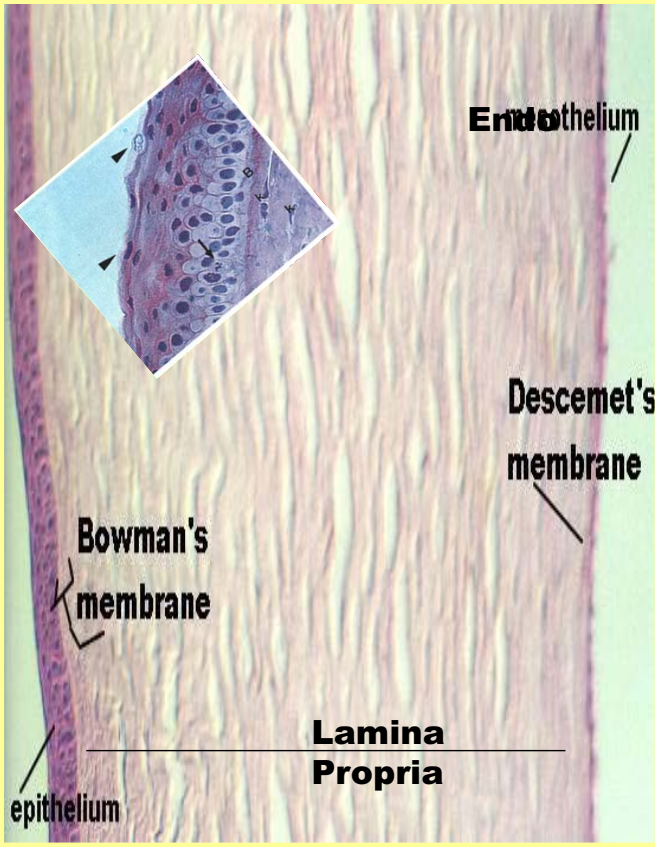
continuous with the sclera at the limbus - has greater curvature to make a lens-like structure that provides about 2/3 of the focusing power of the eye.

- **relatively avascular, receives nutrients by diffusion from the aqueous humor**
- **and has a low hydration level in order to maintain clarity.**

THE CORNEA IS COMPOSED OF 5 LAYERS

1. EPITHELIUM

- Outermost layer of **stratified squamous non-keratinizing epithelium** (5-6 cells thick, approx. 50µ).
- Cells are connected by intercellular bridges.
- densely innervated with **pain sensitive** nerve fibers responsible for the protective reflexes of blinking and lacrimation

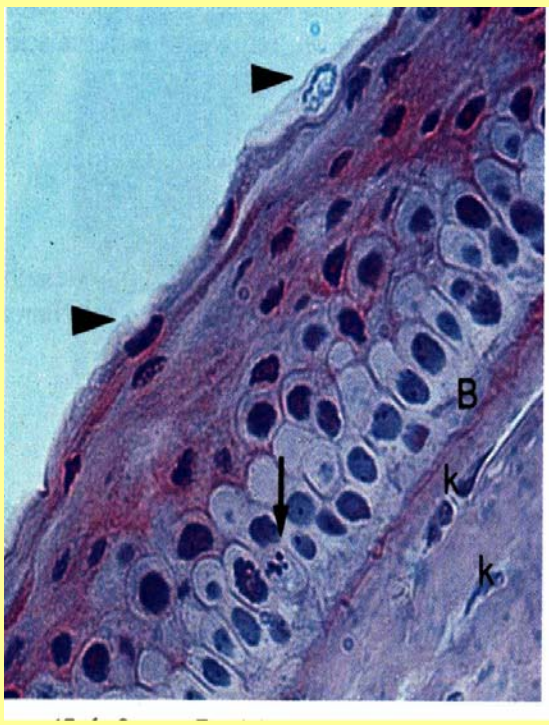


The superficial epithelial cells

-- flat squamous cells connected by **desmosomes**

-- have **microvilli** on their apical surface that maintain a film of moist tears over the cornea.

-- the tear film is renewed after each eyeblink.



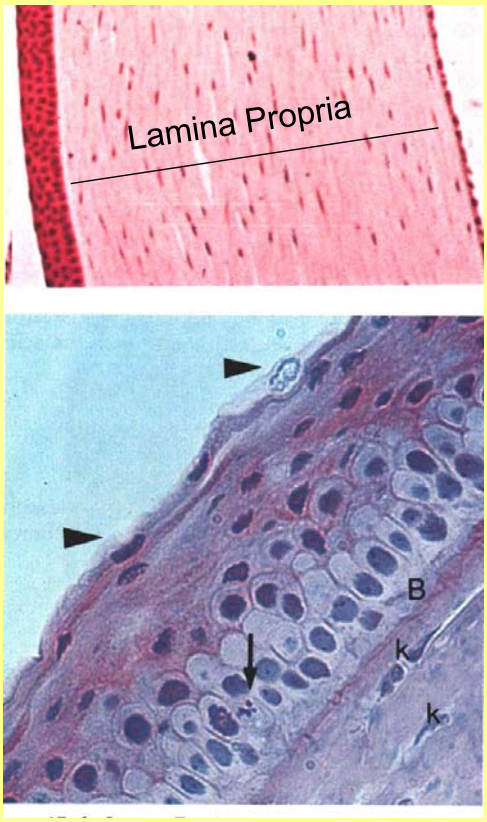
- **Basal cells** of the corneal epithelium

-- are ***capable of rapid mitotic division*** to replace damaged corneal tissues. Turnover time for these cells is 7-10 days

2. **BOWMANS MEMBRANE: thin (8-10μ) acellular layer composed of randomly arranged collagen fibers closely adherent to the basement membrane of the overlying epithelial cells.**

   - **serves as a protective barrier against bacterial invasion.**

3. **LAMINA PROPRIA: Thickest layer (90% of the cornea) consists of regularly arranged lamellae of collagen fibrils (type I collagen), fibrocytes, and amorphous ground substance (mostly keratin and chondroitin sulfates).**



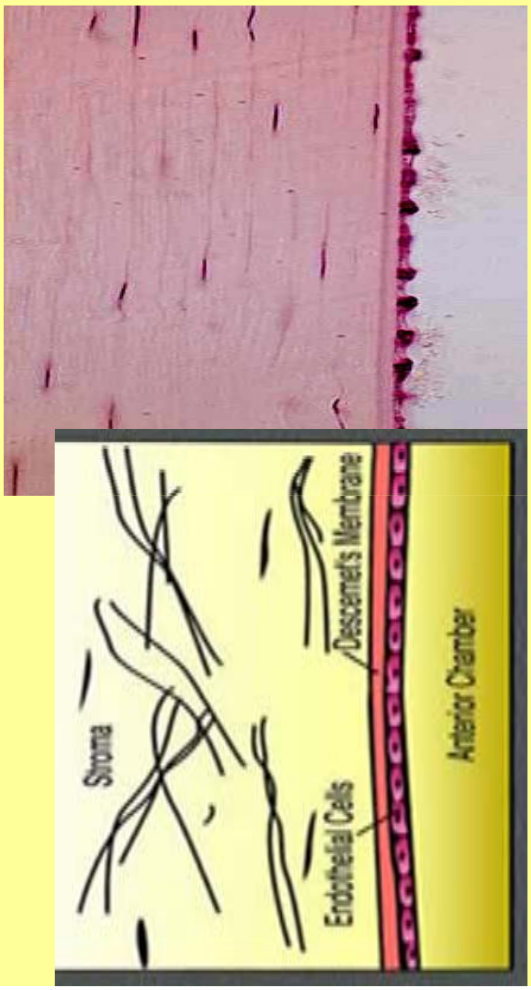
4. **DESCEMET'S MEMBRANE: thick basement membrane of the final endothelial layer.**

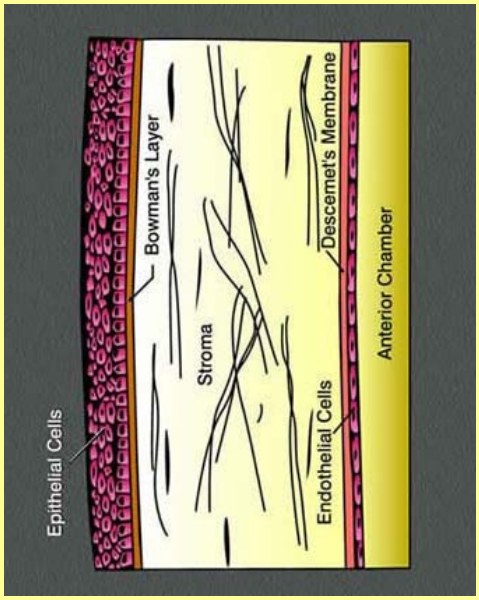
5. **CORNEAL ENDOTHELIUM: simple squamous inner lining of the cornea**

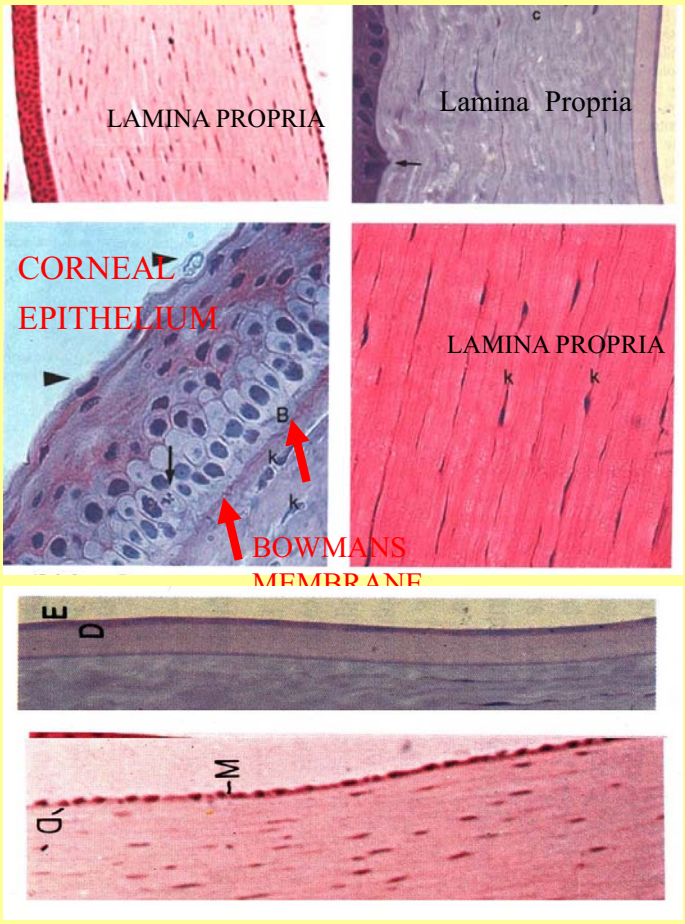
-- **actively transports water (transcellular endocytosis) out of the stroma to maintain corneal clarity.**

- **These are plate-like endothelial cells linked by desmosomes and occluding junctions.**

- **The endothelial cells are responsible for secreting Descement's membrane to which they are bound by hemi-desmosomes.**





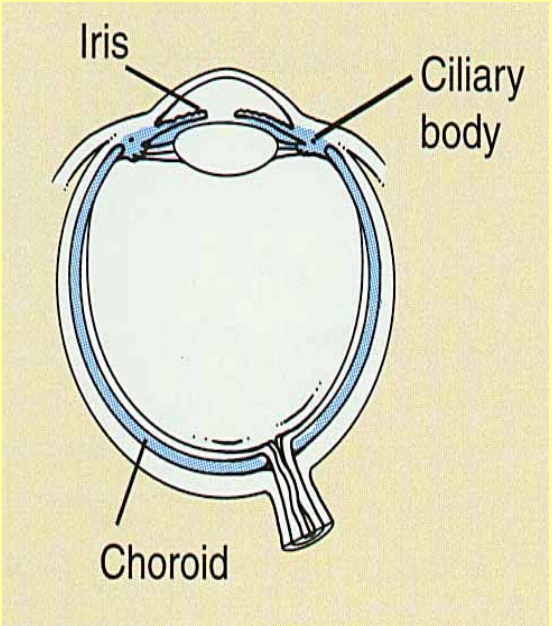


UVEAL (Vascular) COAT:
vascular structures of the eye

Choroid Layer -- Iris -- Ciliary Body

CHOROID LAYER this is the vascular layer of the eye.

just internal to the sclera -- extends posteriorly from the ciliary body across the entire posterior aspect of the eyeball.



- **4 layers of connective tissue containing numerous blood vessels, melanocytes.**
- **Fenestrated capillaries allow tissue fluid to circulate freely in the CT.**

1. **Suprachoroid Layer:**

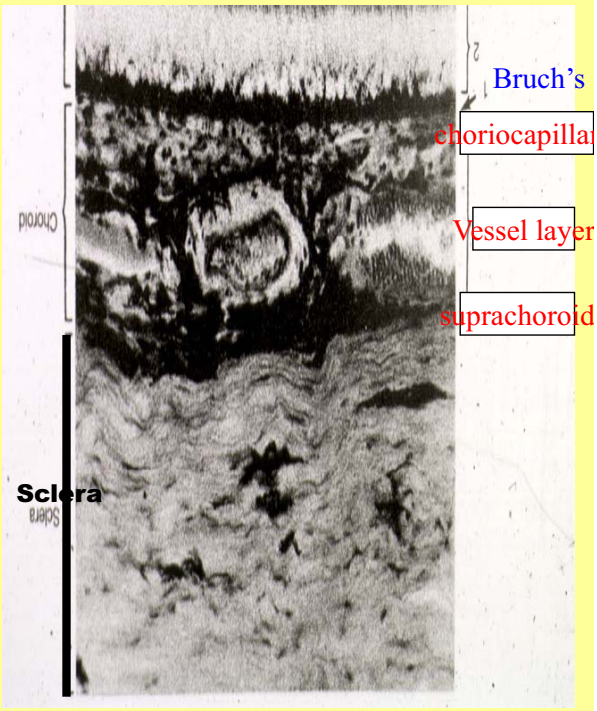
-- **immediately adjacent to the inner sclera -- loose connective tissue with elastic fibers which anchor it to the underlying sclera**

2. **Vessel Layer:**

-- **CT stroma with a higher collagen content than suprachoroidal layer**

-- **contains numerous "*choroidal arteries*" and "*choroidal veins*".**

-- ***numerous melanocyte* which serve to absorb scattered light**



3. **Choriocapillaris:**

-- **single layer of wide fenestrated capillaries which nourish the surrounding tissues including the outer 1/3 of the adjacent retinal coat**

4. **Bruch's (Glassy) Membrane:**

-- **network of collagen and elastic fibers sandwiched in between the basement membranes of the *choriocapillaris* on one side and the *Retinal Pigment Epithelium* on the other.**

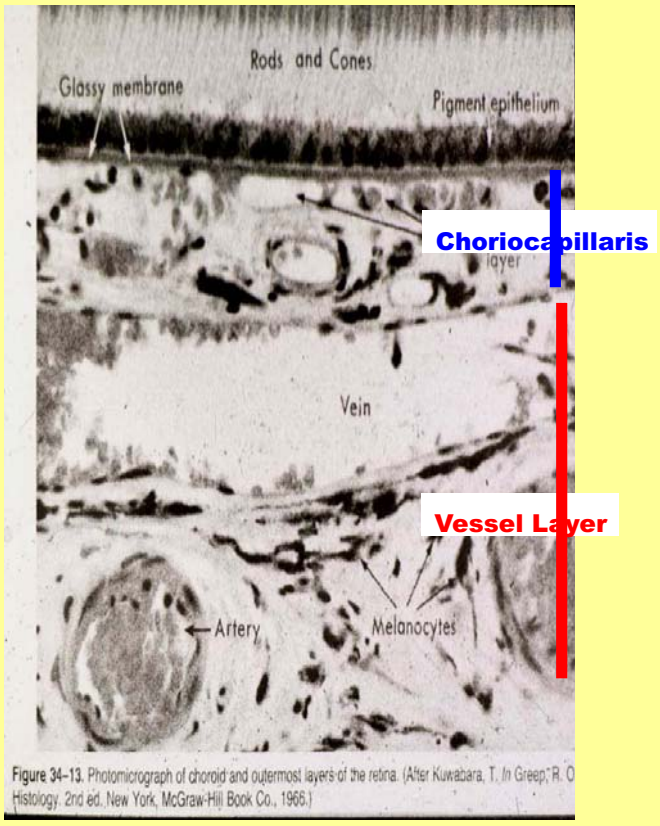
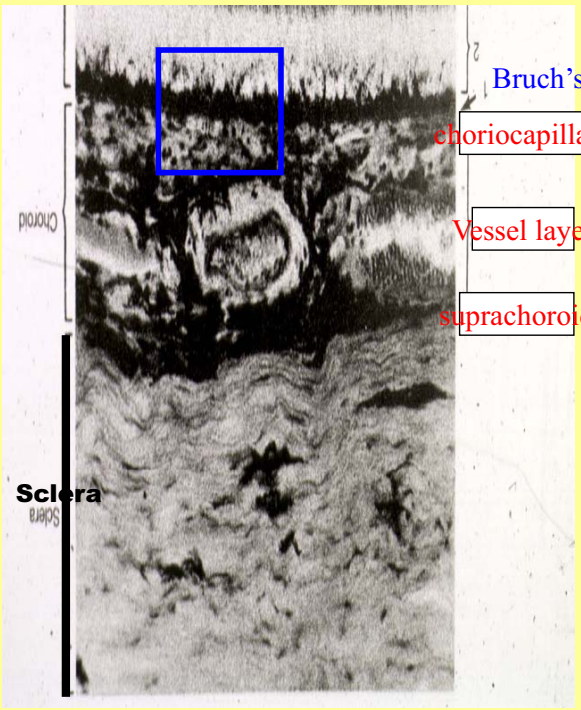
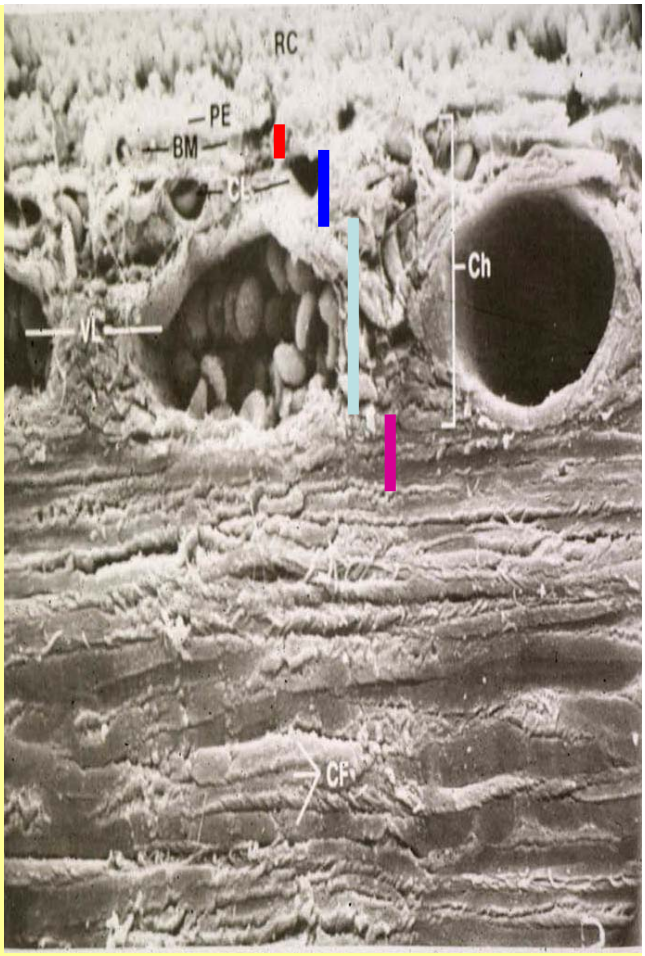


Figure 34–13. Photomicrograph of choroid and outermost layers of the retina. (After Kuwabara, T. In Greep, R. O Histology. 2nd ed. New York, McGraw-Hill Book Co., 1966.)



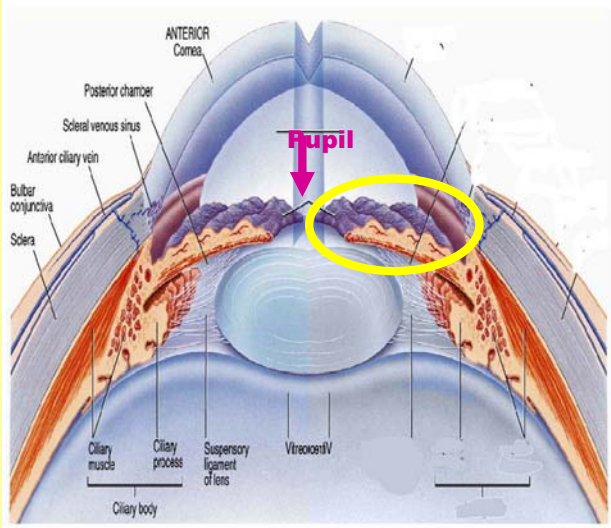


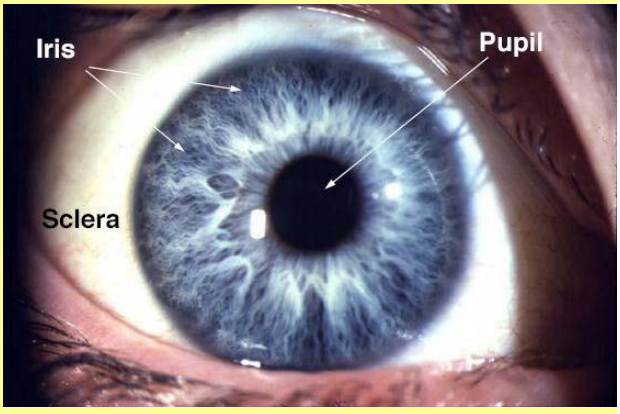
IRIS:

Disk shaped diaphragm situated between the anterior and posterior chambers of the eye. The

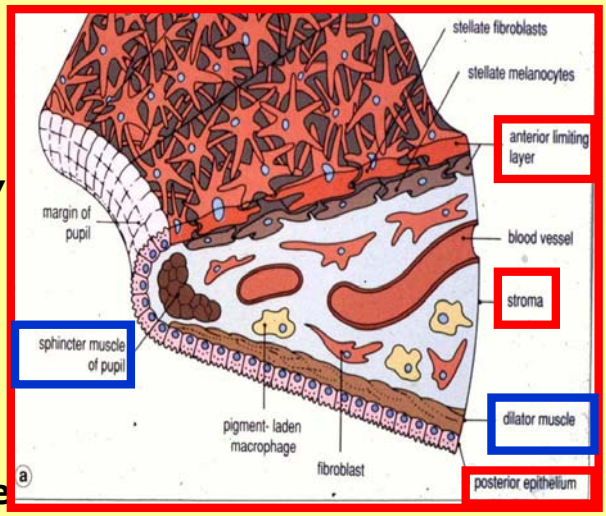
A central aperture in the Iris called the PUPIL allows light to enter the central chambers of the eye.

adjustment of pupil aperture modifies the amount of light that enters the eye permitting vision over a wide variety of light intensities.





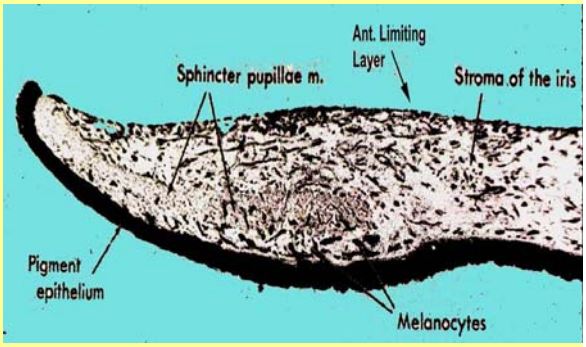
Iris is divided into 4 layers:



1. **Anterior Limiting Layer is a discontinuous layer of stromal cells, consisting of stellate shaped fibroblasts and melanocytes**

2. **Stroma: vascularized loose CT containing melanocytes and fibroblasts.**
3. **Muscular Layer: Two bands of smooth muscle are embedded in the stroma of the Iris:**
   - ***Sphincter Pupillae* = distinct circular band of SM at the margins of the pupil.**
   - ***Dilator Pupillae* = thin sheet of radially oriented SM near the posterior border of the Iris.**

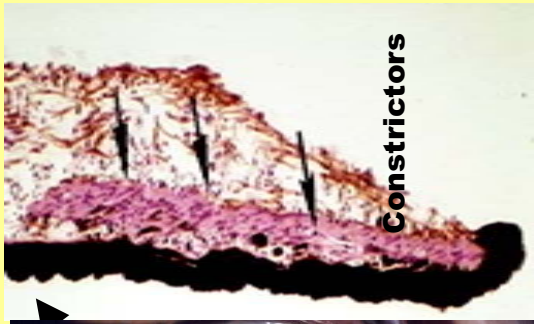
4. **Posterior Epithelium: a double layer of cuboidal pigmented cells**



Size of the Pupil aperture:

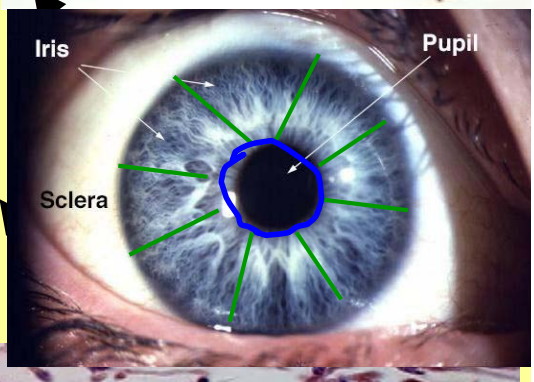
Reduced:

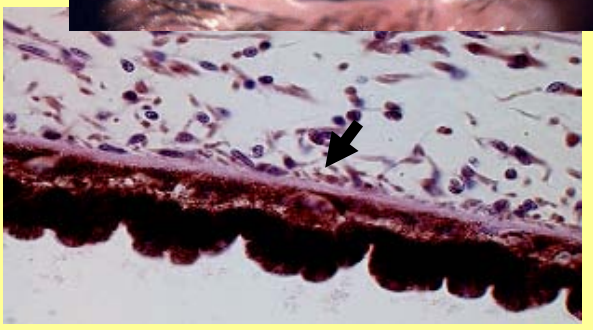
- **by contraction of the sphincter papillae, around the margin of the pupil under control of the Parasympathetic Nervous System.**



Increased

- **by contraction of the myoepithelial pupillary dilator muscle, oriented as a radial sheet of cells (like the spokes of a bicycle wheel) under control of the Sympathetic Nervous System.**





The epithelial cells of the iris are heavily pigmented with melanin to prevent light from entering the eye, except through the pupil, and to reduce light scattering in the interior of the eye.

Eye color results from varying amounts of melanin *in the stroma* of the iris against the dark background of the heavily pigmented cells in the posterior epithelium.

- reduced melanin = blue eyes
- increased melanin = brown eyes

CILIARY BODY

thickening of the Choroid which forms a ring around the eye on the inner aspect of the sclera just behind the Iris

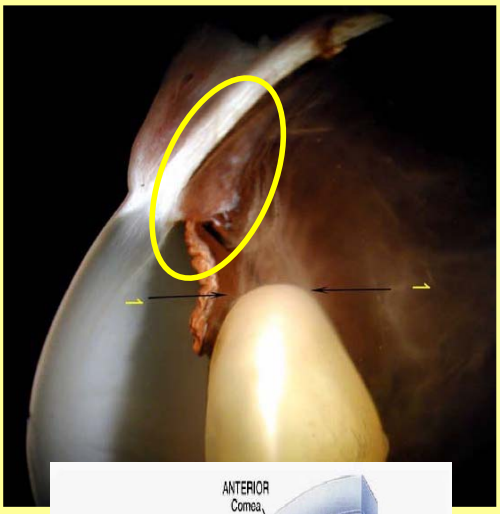
loose CT and Smooth Muscle covered by a double cuboidal epithelium consisting of a

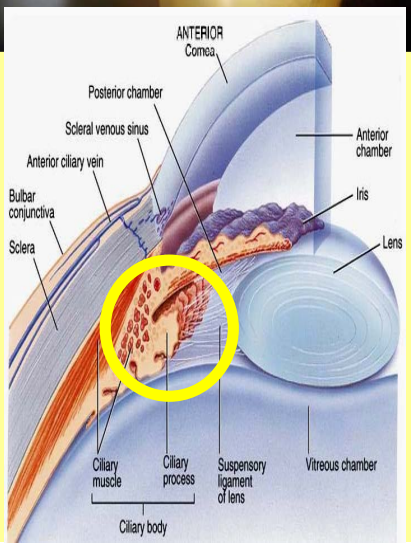
-- superficial non-pigmented layer

-- deep pigmented layer.

The apical surfaces of these two cell layers face one another
(Basement membrane on both sides)

- **connected by desmosomes.**
- **Numerous fenestrated capillaries within the underlying connective tissue.**



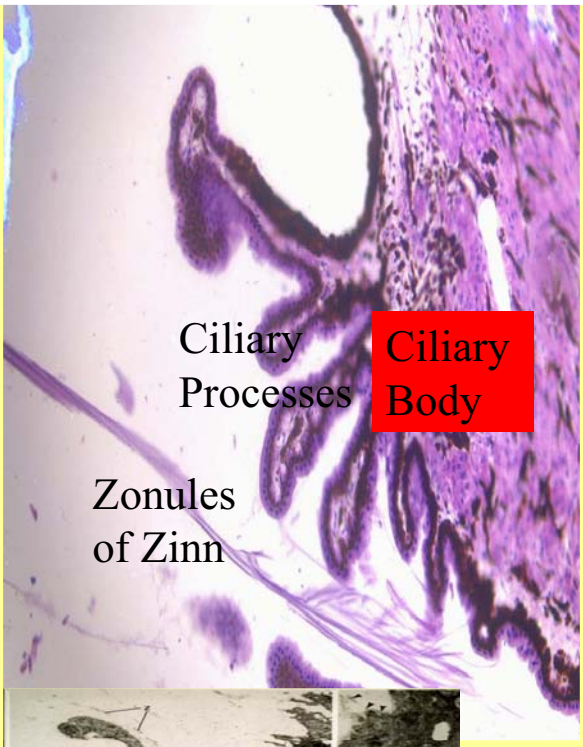


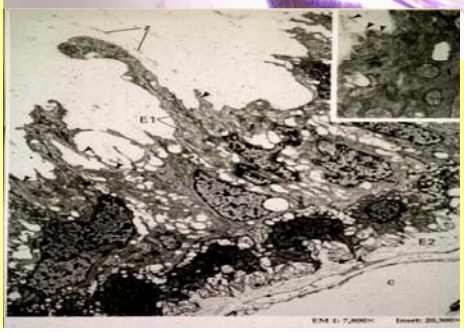
The inner edge of the ciliary body terminates in a series of slender ridges = **CILIARY PROCESSES**

these are attached to the suspensory ligaments of the Lens via a series of slender fibrillar processes = **Zonules of Zinn.**

The outer edge of the ciliary body is anchored to the choroid layer from which it emerges

ciliary muscles attach to choroid anteriorly





Ciliary body has 2 important functions

1. vessels in this structure are the source of the aqueous humor of the anterior and posterior chambers of the eye

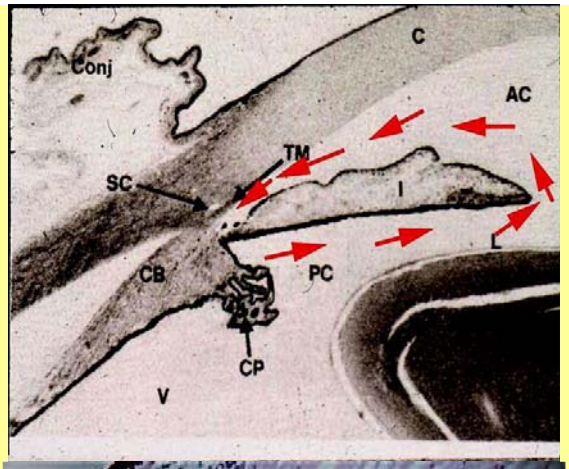
   Aqueous Humor is filtered out of blood vessels into the posterior chamber by the capillaries of the ciliary processes. - Chief source of nutrients for the avascular lens and cornea

   The aqueous humor is transported out of the interior of the ciliary body by the pigment epithelial cells of the ciliary body whose basement membrane provide a "blood-aqueous barrier".

The aqueous humor flows through the posterior chamber into the anterior chamber.

It is drained from the anterior chamber by passing through network of fibrous channels in the lateral aspect of the ciliary body termed the Microtrebecular Meshwork.

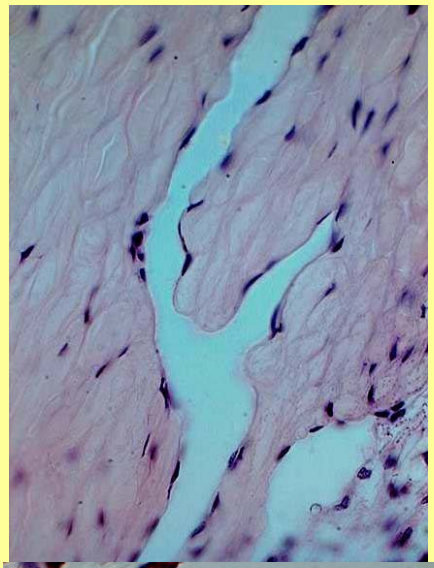
From the sieve-like meshwork the aqueous humor empties into the annular Canal of Schlemm located near the attachment of the ciliary body to the sclera.

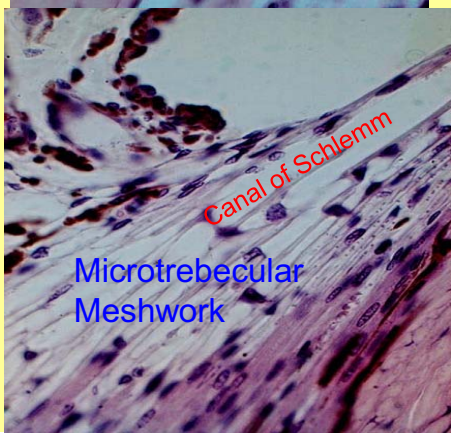


-- This canal is lined with a simple squamous epithelia and runs circularly around the cornea in the CT of the sclera.

-- From the canal, aqueous veins carry the fluid to the conjunctiva, to be released into venous blood.

Blockage of aqueous drainage can result in increased intraocular pressure (glaucoma) resulting in decreased blood flow and ischemia of the retina = blindness.





2. **The second function of the ciliary body is to regulate the shape of the lens via the action of the "ciliary muscles" to accommodate the eye for close and distant vision**

These muscles are controlled by the parasympathetic NS

contraction of the ciliary muscles results in the release of tension on the attached zonules of Zinn and a rounding of the lens for close vision.

When the eyes are at rest:

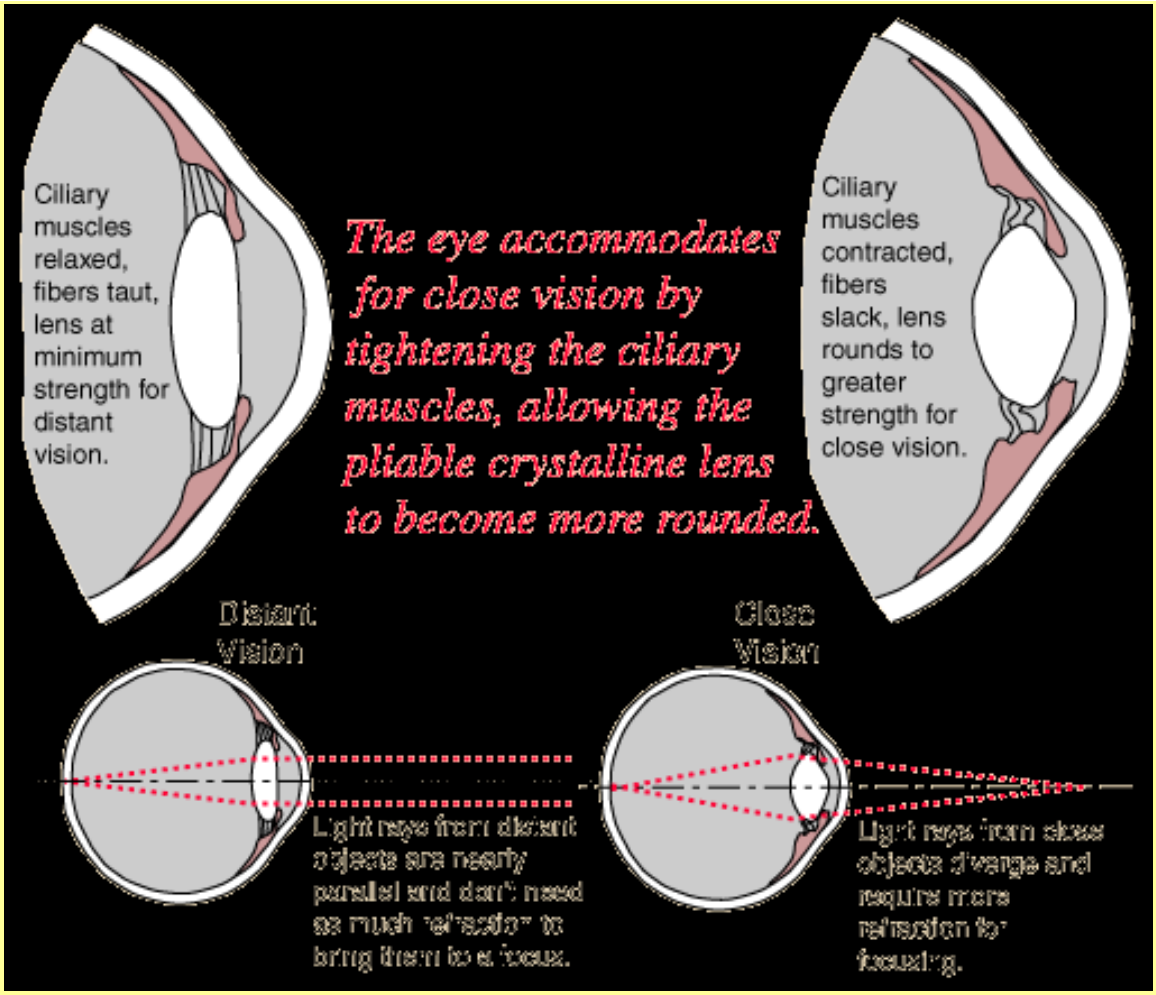
- (accommodated for distance), the elastic choroid pulls the ciliary body backward, where the eyeball has a larger diameter, thus pulling outward and backward on the zonules of Zinn

The ciliary muscles attach anteriorly to the sclera just underneath the iris at the limbus.

During accommodation for near vision,

-- the ciliary muscles contract to stretch the choroid and pull the zonular attachments forward, to a region of smaller diameter of the eyeball, which releases tension on lens for near vision.

-- The lens is pulled back and forth during accommodation, but this is restricted by the iris.



This is sometimes a difficult concept to grasp, so for purposes of study, <u>what you need to know</u> is:

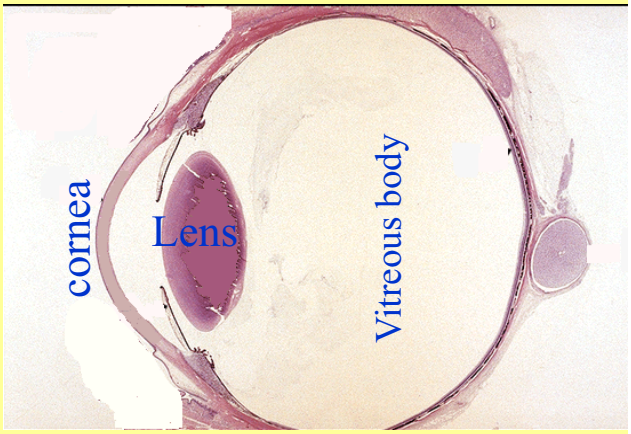
for accommodation to near visual objects, the

- **parasympathetic NS causes the ciliary muscles to contract in a manner that releases tension on the zonules of Zinn,**
- **This allows the lens to increase its focusing power by increasing its curvature.**

For distance vision

- **the ciliary body is relaxed, and the lens and Zonules of Zinn are stretched by the natural tension of the choroidal attachement.**

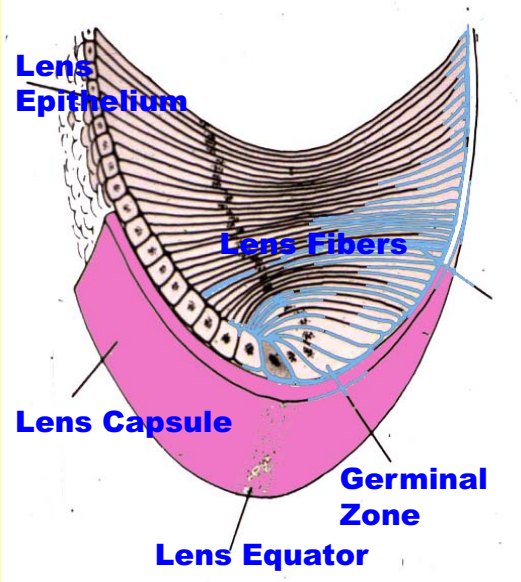
THE LENS:



- Biconvex transparent disk suspended just behind the pupil, attached to the cilliary processes by a set of ligaments = ZONULES OF ZINN (suspensory ligaments)

- The Zonules are composed of microfibrils similar to elastic tissue and are attached to the equator of the lens at one end and the ciliary body at the other end.

The anterior surface



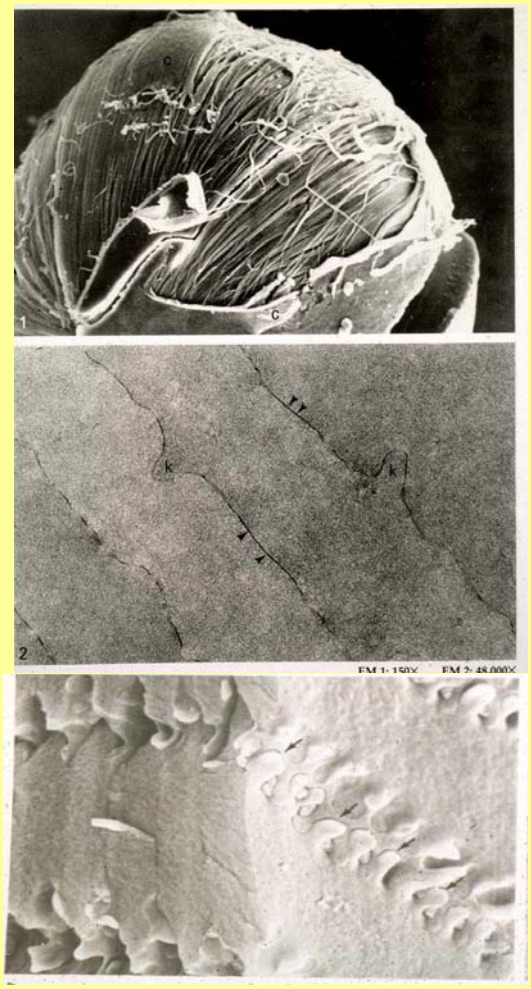
- acellular elastic capsule (type IV) collagen and proteoglycans associated with the basement membrane of simple cuboidal epithelium which lies just deep to the capsule.
- The lens is avascular, contains no CT -- is composed entirely of modified epithelial cells (lens fibers).
- The epithelial cells form a Germinal Zone at the equatorial rim of the biconvex surfaces of the lens and cells continue to divide slowly throughout life and are added to the margins of the lens.

deep to the epithelium, lens cells lose their nucleus and intracellular organelles, and elongate into transparent structures called **LENS FIBERS**,

these make up the body of the lens. The cytoplasm of lens fibers is packed with transparent proteins called **CRYSTALLINS.**

The lateral borders of these fibers are connected by **Knob and socket-like depressions** containing **"tight junctions"** and **"gap junctions"**.

Fibers at the center of the lens persist throughout life and **are not replaced.**



The lens provides about 1/3 of the focusing power of the eye, and all of the **ACCOMMODATION** by changing its shape. It is soft and will round to a lens of greater power if left alone.

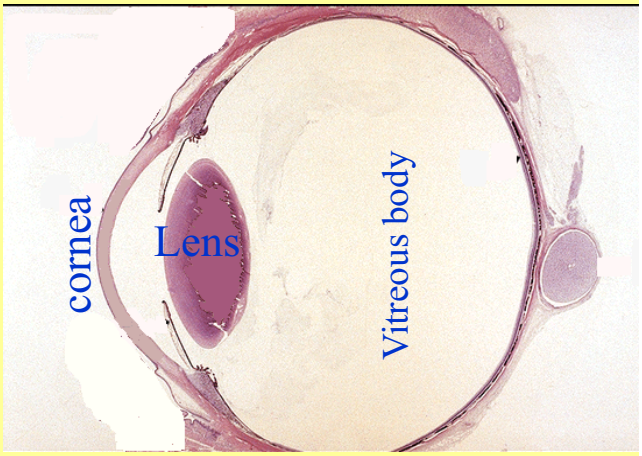
At rest, the lens is stretched to a flatter shape, of less power, by the zonules of Zinn. In this resting state the flatter lens **accommodates the eye for distant vision.**

With age, the lens fibers harden and the lens losses its ability to change shape. This condition, called **PRESBYOPIA,** results in the necessity of reading glasses or bifocals.

The lens may also become semi-opaque with age, a condition known as **CATARACTS**, resulting in a blurred vision.

VITREOUS CHAMBER:

Large space laying behind the lens, between the lens and the retina. It contains the vitreous humor or body.



The vitreous body is a clear amorphous ground substance (GAGS) and thin randomly disposed collagen fibrils, with a high water content (90%).

It has the consistency of soft jello, and is roughly spherical except for the depression at its anterior pole which accommodates the lens.

It is adherent to the peripheral retina and the ciliary epithelium.

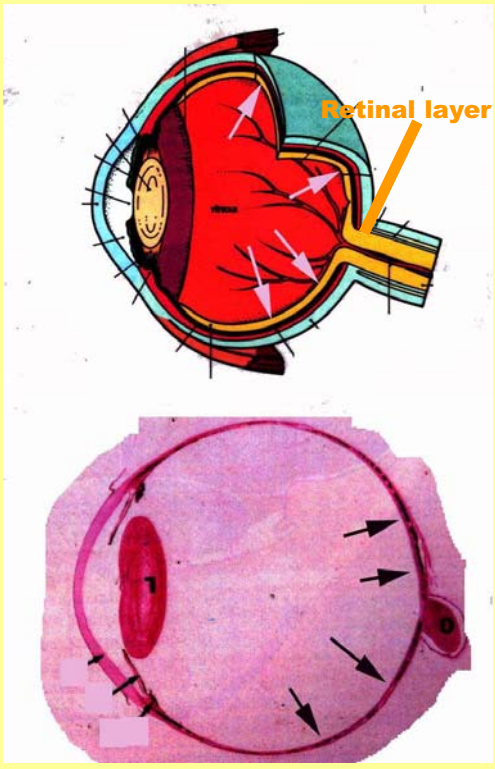
THE RETINA

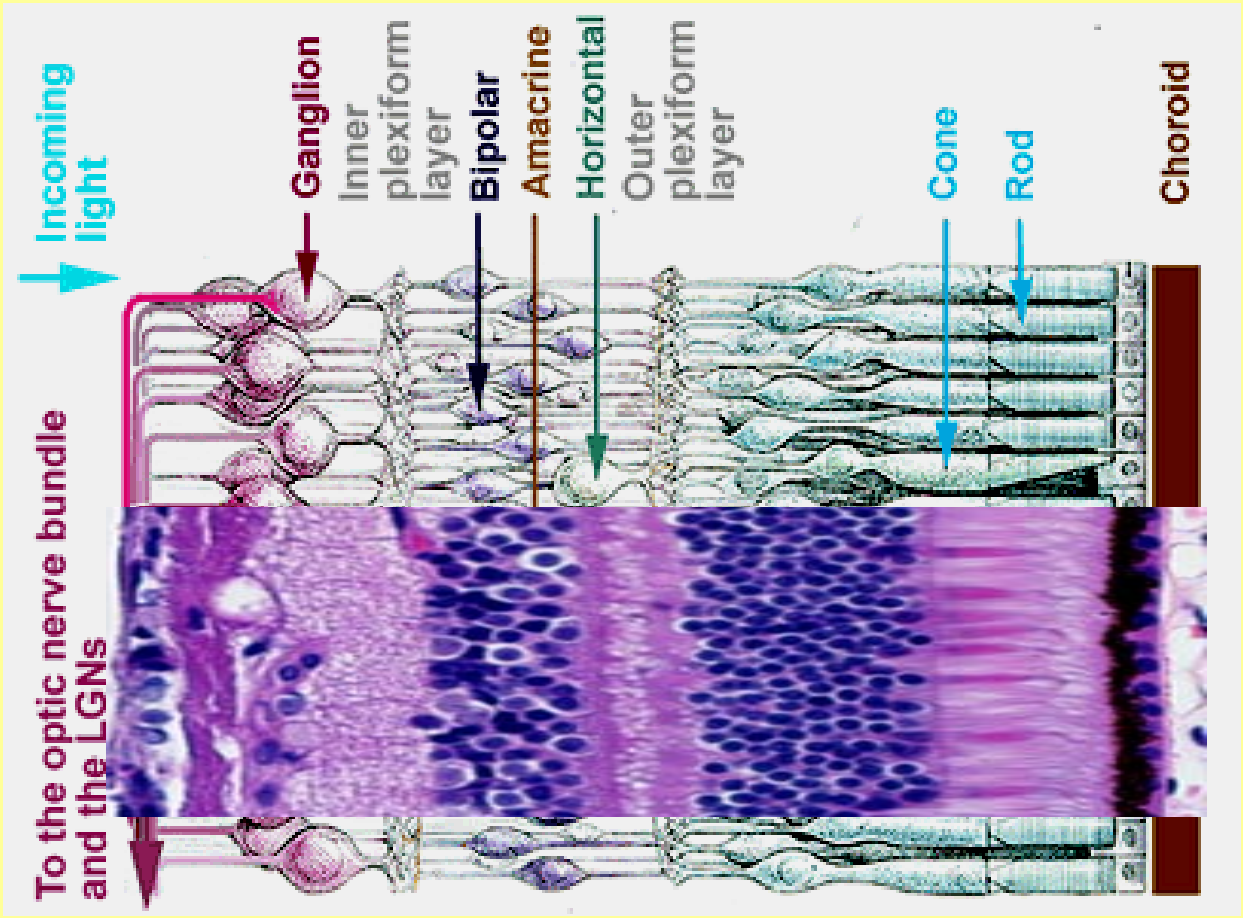
the final optical element, and is the innermost layer of the posterior part of the eye.

It is embryologically a part of the brain and consists of neurons in complex synaptic arrangement.

The retina consists of 10 layers including the pigment epithelium.

One of the counterintuitive aspects of retinal organization is that light must pass through almost all of the layers before it reaches the photoreceptors, and the photoreceptors are oriented so that they point away from the incoming light.





The cells of the neural retina include:
5 neural elements and 1 glial cell

1. **Photoreceptors = light sensitive Rods and Cones**

2. **Bipolar cells =**
   2nd order neurons that receive neural impulse from photoreceptors and transmit them to 3rd order ganglion cells

3. **Horizontal cells**
   2nd order neurons that interconnect photoreceptors laterally

4. **Amacrine cells**
   distribute impulses from bipolar cells laterally to retinal ganglion cells

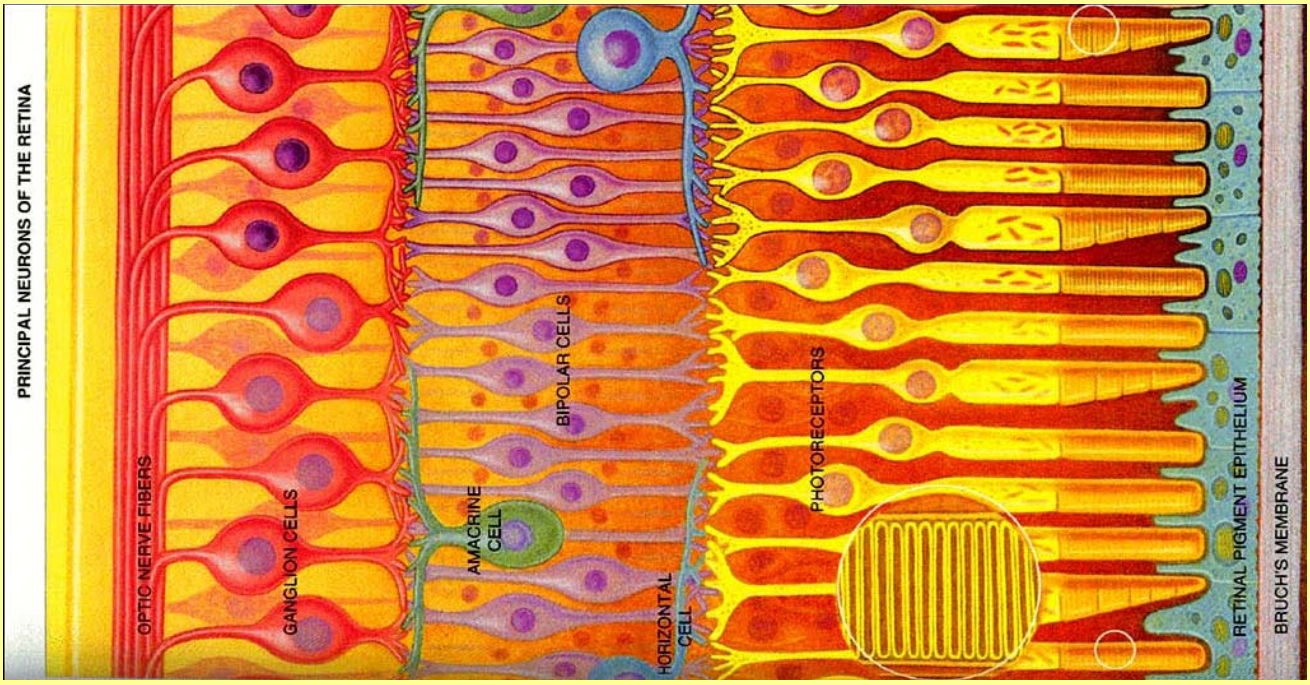
5. Ganglion cells

3rd order cells whose axons exit the retina at the optic disk to form the optic nerve conveying visual information to the CNS.

-- Muller cells (Glial)

large *glia cells* that extend throughout all 10 layers of the retina. Their apical cytoplasmic processes wrap around the photoreceptor serving to insulate them from one another. Their nuclei are found in the inner nuclear layer.

Retinal cell types are not clearly distinguishable in standard H&E preparation except that in some instances their nuclei reside in specific layers.



LAYERS OF THE RETINA:

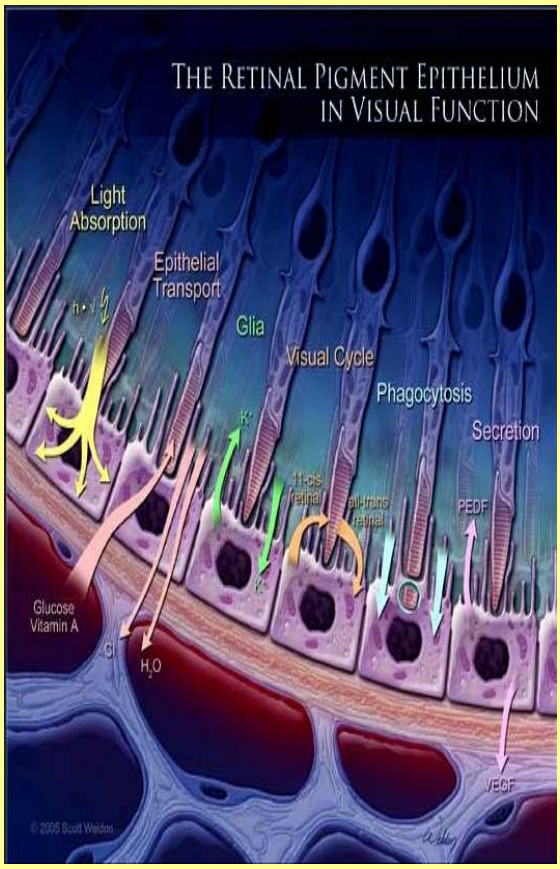
1. RETINAL PIGMENT EPITHELIUM:

A single layer of cuboidal-columnar cells that lies between the retina and choroid in the posterior portion of the eye and extends over the ciliary body and the posterior Iris.

functionally this layer is related to both the choroid and the retina. Resembles a simple cuboidal epithelium of the choroid, but it has no free surface under the retina.

The base of these cells are attached to Bruch's membrane of the choroid.

The apical surface of the cells have microvilli and cylindrical cytoplasmic sheaths that enclose the ends of retinal photoreceptors) and nourish the outer segments of rods and cones and phagocytose pieces of their outer segments which are constantly shed.

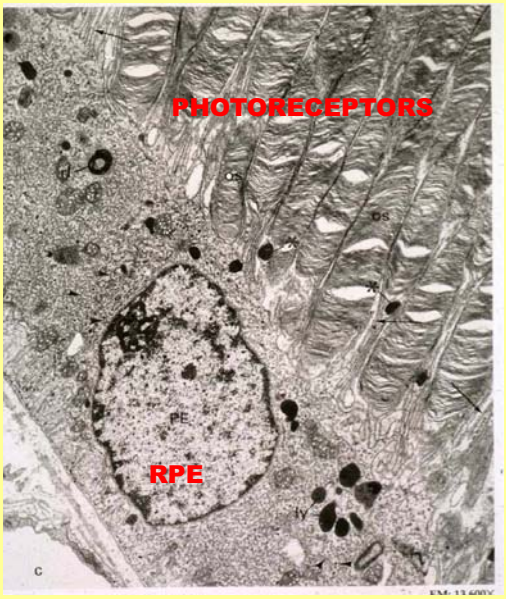


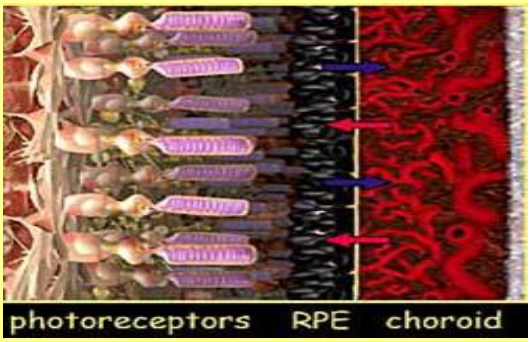
The epithelial basement membrane, and well developed "tight junctions" between the cells, provide a BLOOD / RETINA BARRIER.

The cells contain MELANIN granules that, along with the choroid pigment, prevents light from being scattered in the back part of the eyeball.

There is no firm attachment between the RPE and the underlying Photoreceptor layer and following head trauma, they may separate, causing a detached retina.

This condition results in the slow death of the photoreceptors if the retina is not surgically reattached.

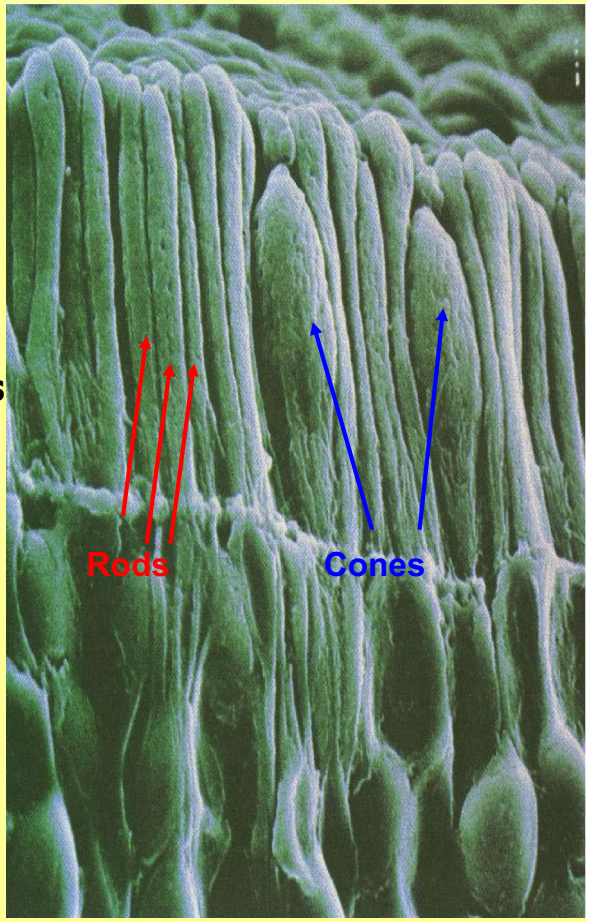




2. PHOTORECEPTOR LAYER

The photoreceptor layer is populated by cells specialized for the transduction of light energy into neural impulses.

Two types of photoreceptive cells -- Rods and Cones named for the shapes of their outermost segments.



PHOTORECEPTOR CELLS HAVE 6 PARTS.

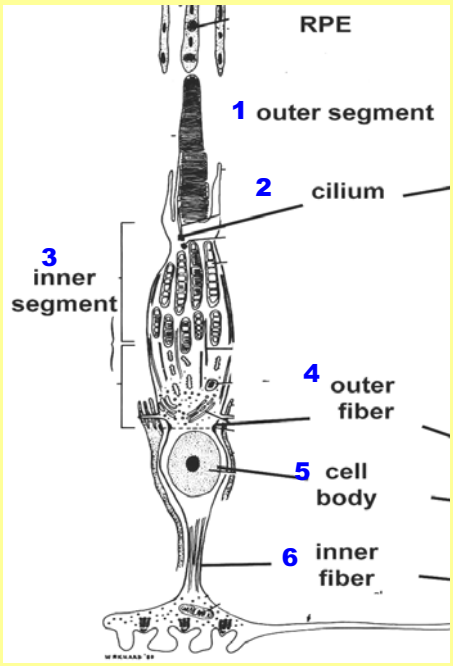
1. OUTER SEGMENT

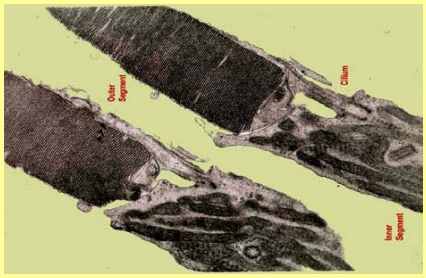
-- broad and tapered in cones,

-- long, narrower, and straight in rods.

composed of dense vertical stacks of membrane bound disks which arise from the repeated infolding of the apical surface of the cell membrane.

This is the light-sensitive region of the receptors. These are constantly being turned over with the ends sloughing off to be phagocytosed by pigment epithelial cells.





The disks of the photoreceptor outer segments contain a vitamin A derivative photopigment (light sensitive) composed of retinene and opsin.

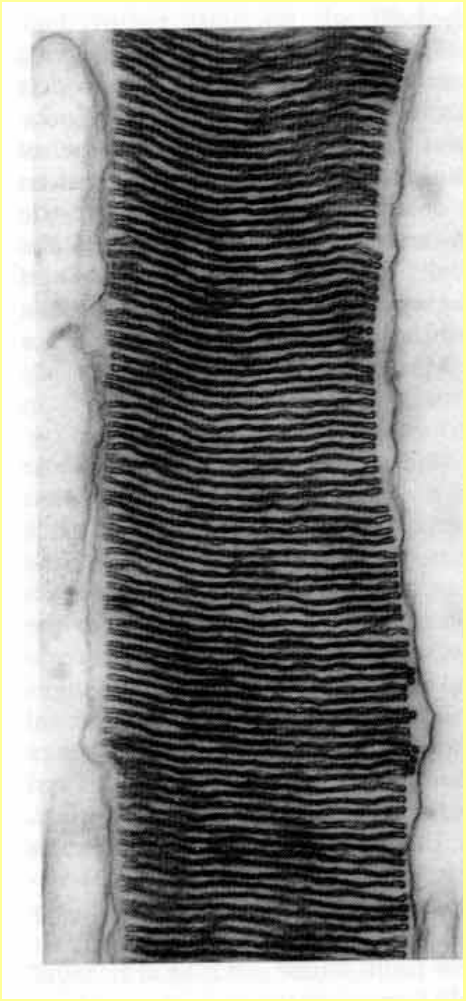
-- The rod photopigment is called rhodopsin and

-- cones contain three varieties generically termed photopsin (iodopsin).

The rod pigment -- sensitive to dim light (scotopic vision).

The cone pigments are sensitive to bright light levels (photopic vision) of either red, green, or blue light.

-- The rods support night vision
-- cones support daylight color vision.



2. CILIUM:

Just below the outer segment is a small slender CILIUM containing nine peripheral microtubule doublets.

This structure unlike other cilia is non-motile and lacks the central pair of microtubule seen in motile cilia.

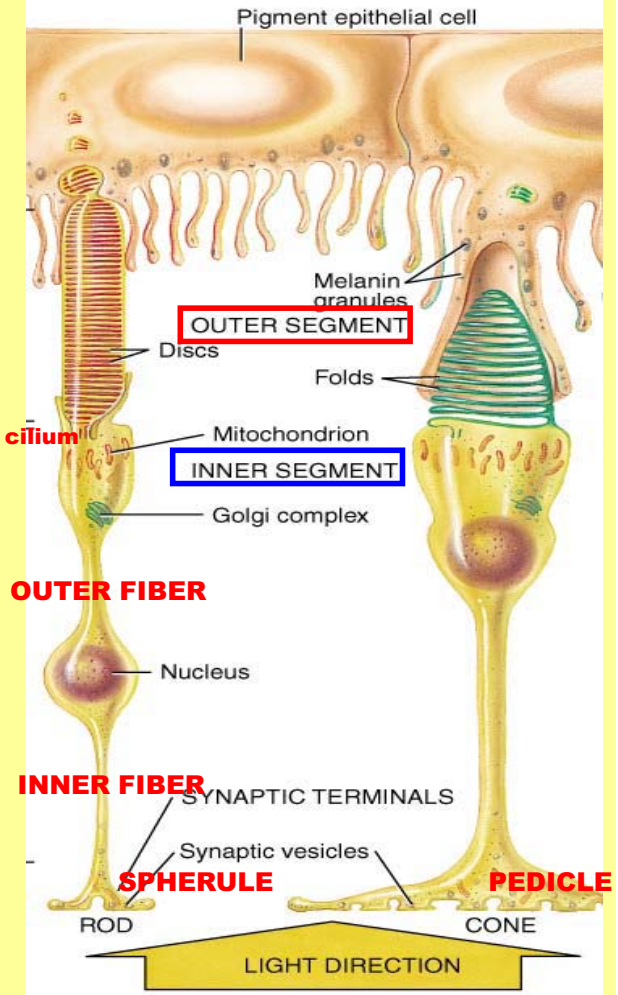
The cilium connects the outer segment to the adjacent inner segment. The photoreceptor disks are thought to arise from a specialization of the cilium.

3. INNER SEGMENT:

A slightly thicker ellipsoid-shaped region of the cell which contains **most of the intracellular organelles** (except the nucleus).

The membrane of this region contains numerous **K+ channels** which are active during phototransduction.

The inner segment of the receptors is the metabolic portion of the cell body and contains many mitochondria, Golgi , and the usual complement of other organelles.

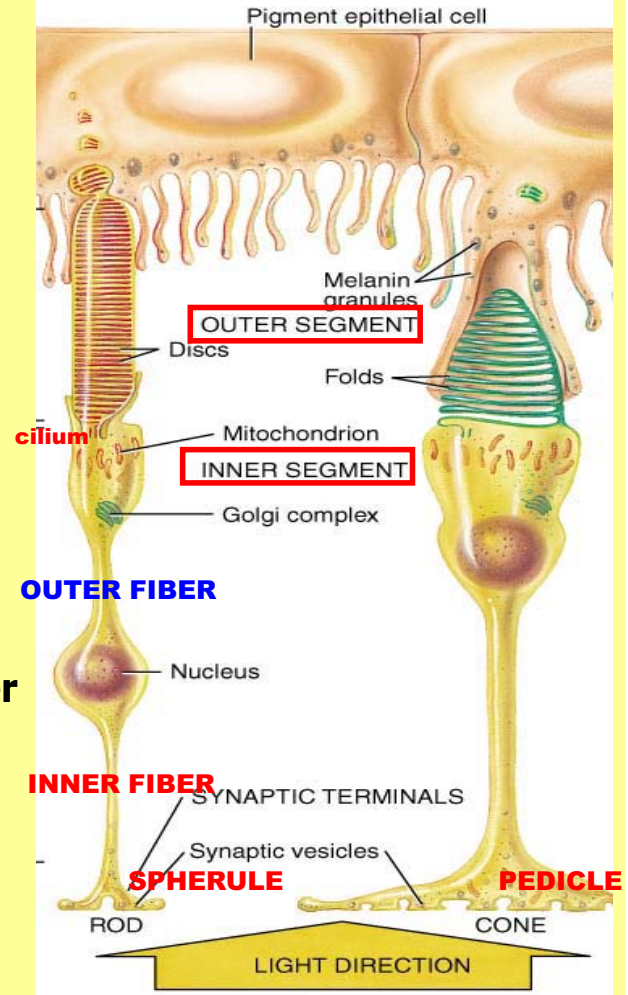


4. OUTER FIBER:

The inner segment of the photoreceptors are connected to the cell body by a thin process known as the **OUTER FIBER**.

The outer fiber is surrounded by the processes of the apical surfaces of adjacent supporting cells called **Muller cells.**

Muller cells processes are connected by **tight junctions** in this region giving thickened appearance termed the **EXTERNAL LIMITING MEMBRANE.** The outer fiber is much less prominent in cones.



5. CELL BODY:

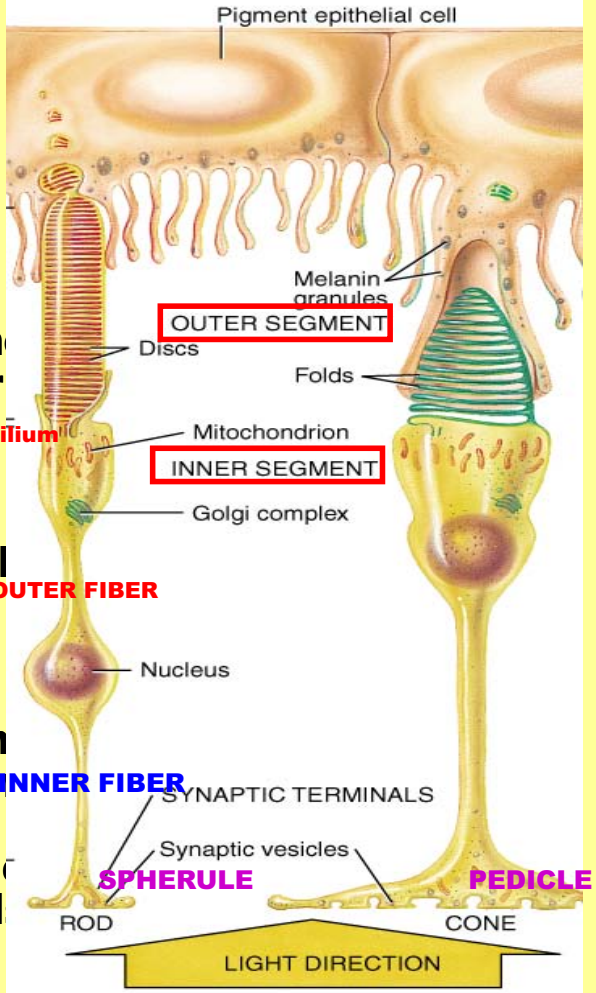
The **CELL BODY** proper of the photoreceptors is filled almost entirely with the nucleus.

6. INNER FIBER

Extending from the cell body of th photoreceptor is a second slender process, the **INNER FIBER**.

This fiber terminates in a specialized expanded region whic forms synaptic contact with the underlying bipolar cells.

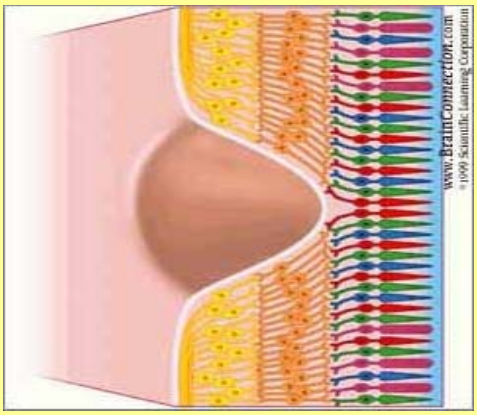
This expanded region is termed th **SPHERULE** in rods and the **PEDICLE** i cones. It contains numerous synaptic vesicles and serves as th presynaptic element for these cell



PHOTORECEPTOR DISTRIBUTION:

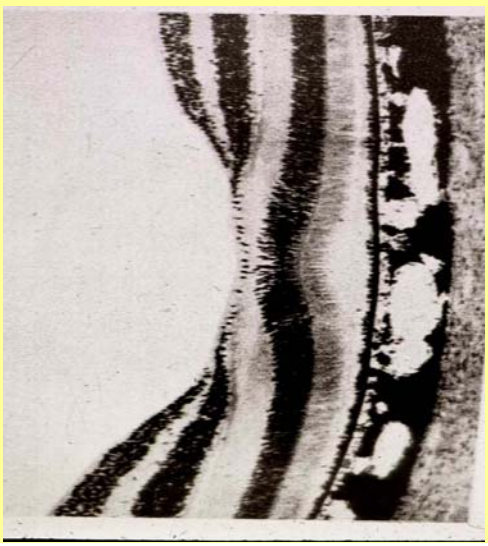
photoreceptor distribution is not random.

The center of the retinal near the exit of the optic nerve exhibits a slight depression called the **FOVEA CENTRALIS**



Cones which give rise the best visual acuity, are most dense in the fovea centralis

This area is devoid of blood vessels and the remaining retinal layer are thinner here. Light can gain easier access to the cones in this central retinal region.

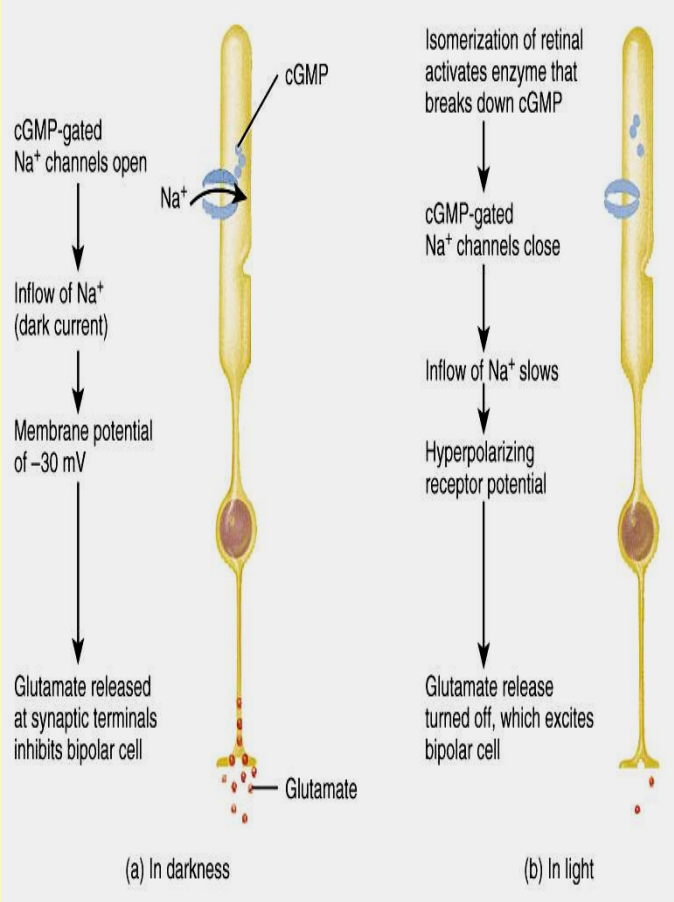


-- Cone predominate in the central retina
-- while rods predominate in the peripheral retina.

RETINAL TRANDUCTION:

Through a complex series of reactions, light striking the outer segments of the rods and cones results in hyperpolarization of these receptors.

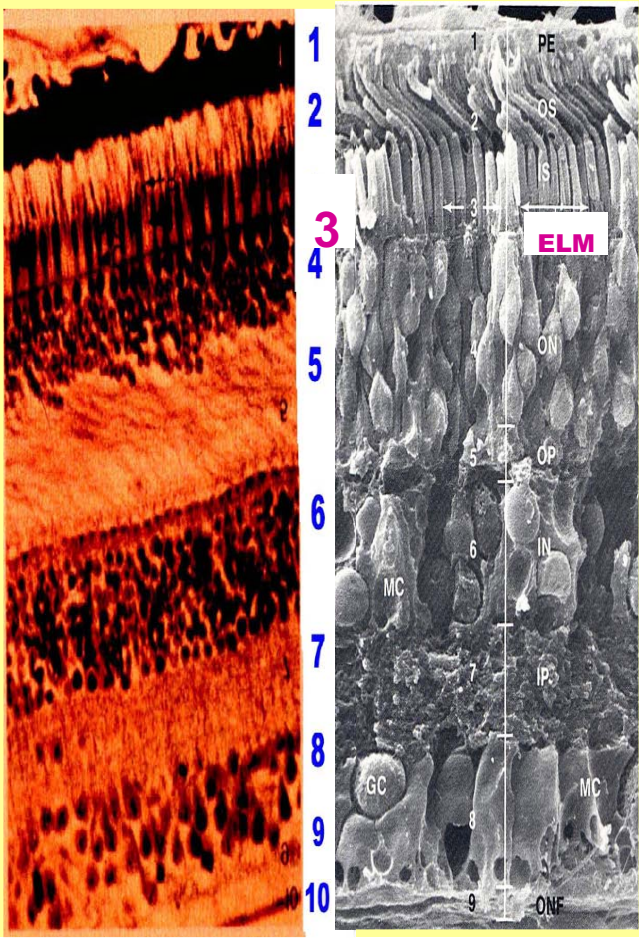
This occurs through a cGMP and Ca+ dependant modulation of Na+ channels in the photoreceptor membrane.



3. EXTERNAL LIMITING MEMBRANE

photoreceptors are surrounded by cells called Muller cells. Muller cells are supportive cells analogous in function to glial cells in the brain.

The external limiting membrane is not really a membrane. EM studies show this element to be composed zonula adherens junctions between the cylindrical cytoplasmic processes of Muller cells and the photoreceptors.



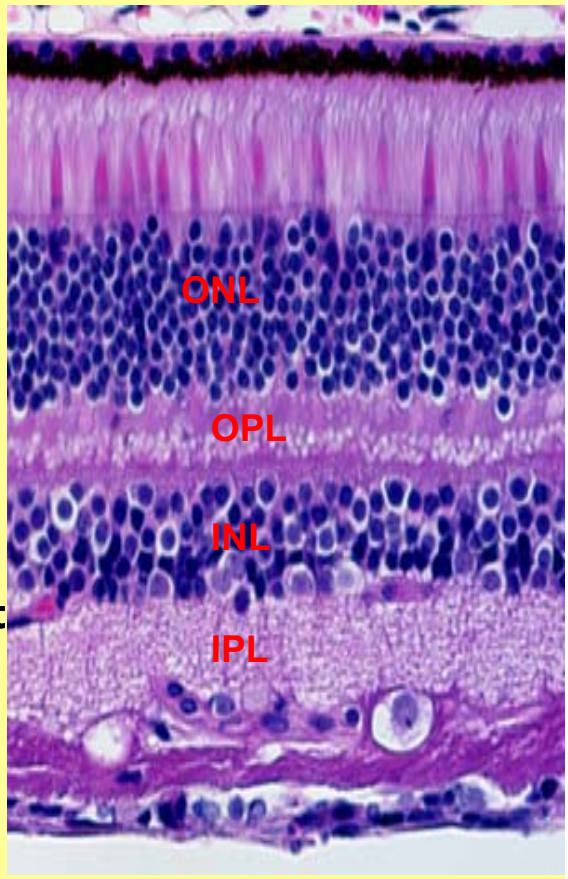
4. Outer Nuclear Layer

Region where the nuclei of the photoreceptor cells (rods and cones) reside. The nuclei are at different distances from the external limiting membrane, giving the layer the appearance of a thick stratified epithelium.

5. Outer Plexiform Layer

This layer contains the basal synaptic processes of the photoreceptors as they make contact with the dendrites of two types of 2nd order cells, the bipolar and horizontal cells.

Devoid of cell bodies, this region appears relatively unstained in LM.

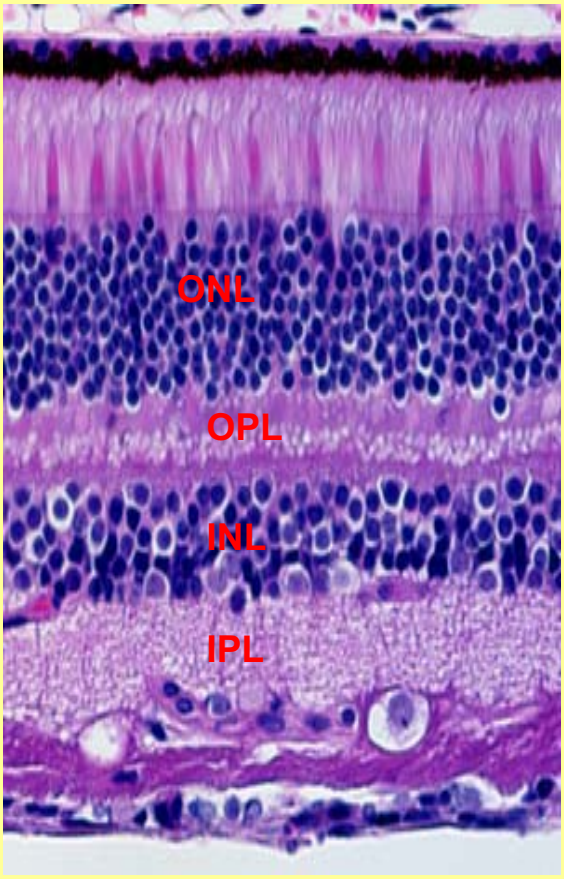


6. Inner Nuclear Layer (Bipolar Layer)

The region where the cell bodies of bipolar, horizontal, and amacrine cells reside. These cells are responsible for the processing of visual signals from the photoreceptors within the retina

7. Inner Plexiform Layer

relatively clear region where the processes of bipolar, amacrine and ganglion cells interact synaptically to process visual information.



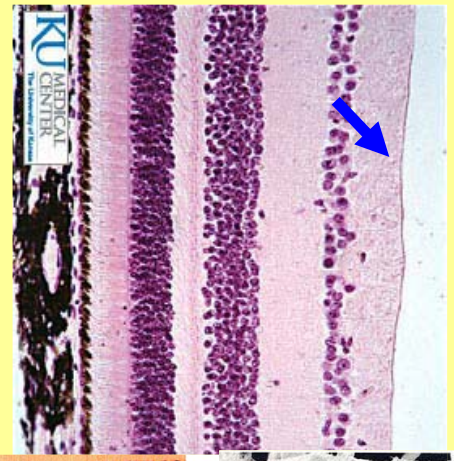
8. Ganglion Cell Layer

contains the cell bodies of the retinal ganglion cells. This layer is variable in thickness.

The retinal ganglion cells are the output neurons of the retina and support a long axon that leaves the retina via the optic nerve to synapse in the CNS.

Retinal ganglion cells are much larger than the other neurons of the retina.

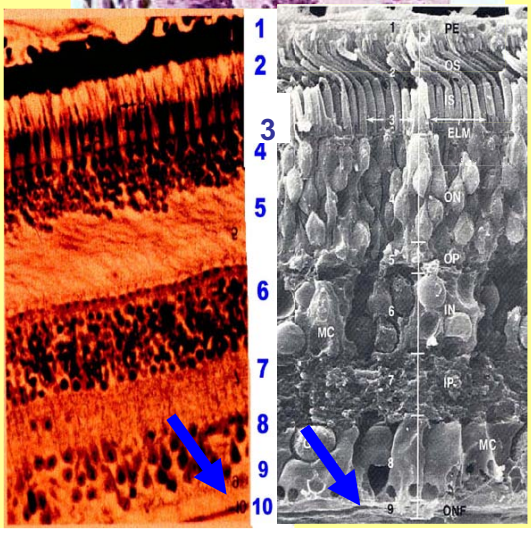
9. Retinal Axon Layer



region where the unmyelinated ganglion cell axons travel toward the optic disc where they exit the eyeball.

After they leave the eyeball they become myelinated to form the optic nerve, which is larger in diameter than the optic disk.

10. Internal Limiting Membrane



Also not a true membrane, but the basement membrane of the supportive Muller cells.

Muller cells span all of the layers of the retina, and their cell bodies lie in one of the cellular regions and cannot be distinguished from the neurons.

NEURAL ACTIVITY IN THE RETINA

-- is principally graded hyperpolarization and depolarization in retinal neurons.

-- only the ganglion cells reliably sustain nerve impulses.

-- The synaptic circuits of the retina encode visual information for transmission to the brain

– This takes the form of varying frequencies of action potentials in the ganglion cell axons.

The retina is therefore the first in many visual processing centers of the brain.

-- If the visual image were not encoded, but rather each axon carried the output of each photoreceptor into the brain, the optic nerve would have to be more than one inch in diameter.

-- photoreceptors are hyperpolarized by light and chronically release neurotransmitter.

-- Light brighter than the environment causes them to reduce the rate of transmitter release.

-- whereas darker regions of a visual scene cause an increase in transmitter release.

The Pathway of Visual Information:

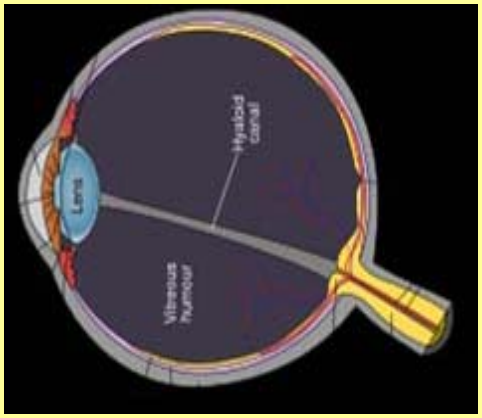
Photoreceptors ------> Bipolar cells ------> Ganglion cells

Horizontal and Amacrine cells mediate lateral interactions across the surface of the retina.

A single ganglion cell is connected to many photoreceptors.

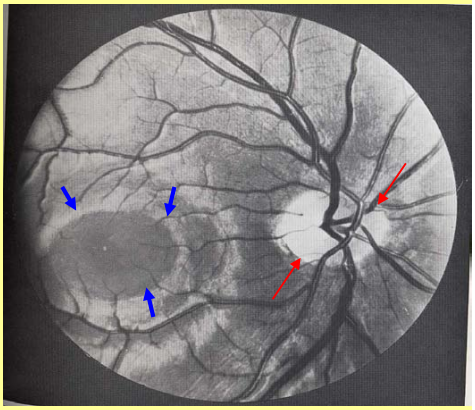
Ganglion cells encode whether a contour or edge is present, its color, brightness, and exact position in space.

THE OPTIC DISK (or PAPILLA)



A circular region near the central portion of the retina where the axons of retinal ganglion cells collect to form the optic nerve.

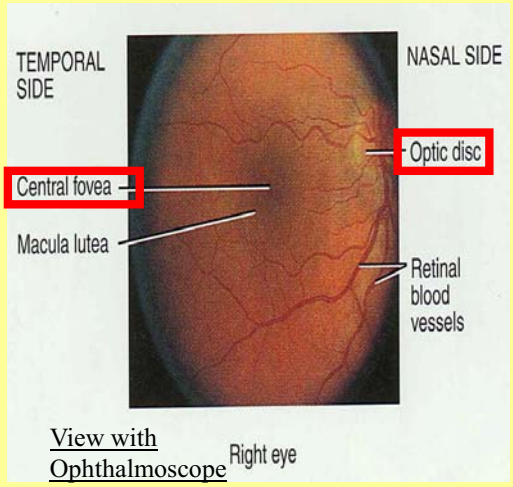
Here RGC axons pierce the parenchyma to leave the eyeball.



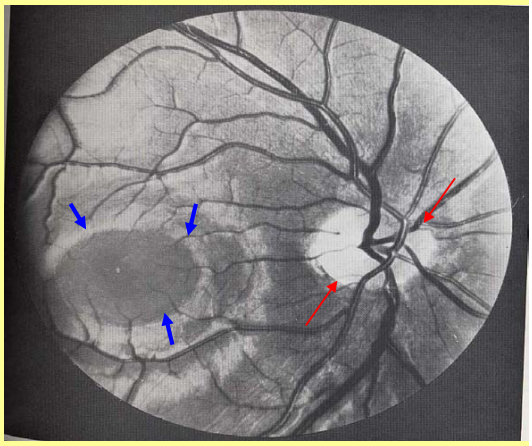
There are <u>no photoreceptors</u> in this region which represents a "blind spot" in visual space.

THE FOVEA

The general architecture of the retina is modified at its center by the appearance of the FOVEA CENTRALIS, a small depression (ABOUT 1.5 MM DIAM.) in the retina where visual acuity is best.



View with Ophthalmoscope Right eye

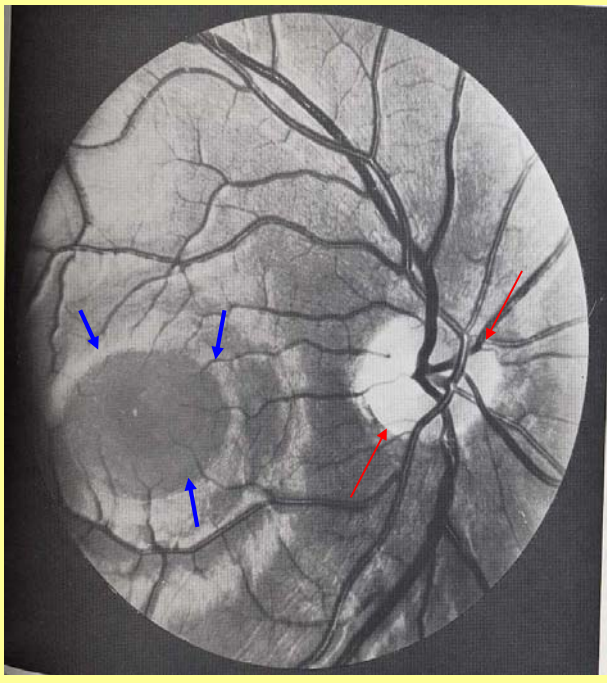


ganglion cells particularly dense in this area, and much of the overlying retinal layers are displaced in this region, forming a depression.

There is a minimum of diffusion of light striking the photoreceptors in this region making this a region of high visual acuity.

This region takes on a yellow color post mortem and is often referred to as the Maculae Lutea (yellow spot).

BLOOD SUPPLY OF THE RETINA:



The RETINAL ARTERY AND VEIN: enter the eyeball at the optic disk.

These vessels bifurcate at the disk to supply the upper and lower portion of the inner 2/3 of the retina, not supplied by the choroid.

Retinal capillaries from these vessels ramify in the ganglion and fiber layers.

Diabetic Retinopathy:

One of the leading causes of blindness in the USA

Uncontrolled plasma glucose in tunics of the eye causes vascular edema & altered retinal and choriodal vasculature

scar tissue-induced retinal detachment

Edema and vascular leakage

Proliferative revascularizarion